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THE EFFECTS OF SCIENCE INQUIRY IN A FOURTH GRADE CLASSROOM

by
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B.S. University of Central Florida, 2000

A thesis submitted in partial fulfillment of the requirements
for the degree of Master of Education in K-8 Mathematics and Science Education
in the Lockheed Martin/ UCF Academy
in the College of Education
at the University of Central Florida
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ABSTRACT

The purpose of this study was to determine the effects that science inquiry would have on fourth grade students' ability to communicate about scientific concepts learned, their perceptions about science and scientists, and my role as a teacher. The study took place in an elementary school setting for twenty weeks. Fourteen fourth grade students participated. Qualitative and quantitative methods were used to gather data for the study. Pre and post questionnaires and Draw a Scientist Tests were used, along with observations, field notes, videotaped lessons, and reflections. The data revealed that students' ability to communicate about science concepts improved during the study. Their perceptions of science and scientists became more realistic. My role as a director of knowledge transitioned into a facilitator.

This thesis is dedicated to my family, whom has offered unconditional support. A special recognition also extends to my professional colleagues for their help and collaboration during the course of the study. To each of you, thank you a million times.

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To Dr. Jeanpierre, I extend my appreciation for all of the hard-work and long hours that were put into reading and re-reading this thesis. Thank you also to Dr. Gresham and Dr. Hynes for serving on my committee. The Lockheed Martin/ UCF Academy experience has impacted my classroom and professional development significantly.

Thank you to the following scientists who visited my classroom during the course of the study, and provided inquiry-driven lessons: Maryann Utegg from the St. John's River Management District, Amy Townsend and Sarah Moorehouse from LPG Environmental, Denise Gainer from Lake County Environmental Services, and Cindy Strickland from Lake Soil and Water Conservation District.

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CHAPTER ONE: INTRODUCTION

Science educators in the United States have long recommended that inquiry be placed at the core of science instruction (National Research Council [NRC], 1996). The focus of this study was to learn the effects of science inquiry methods and constructivist methods on my students' communication about science concepts, their perceptions of science and scientists, and my role as the teacher. Using inquiry-based instruction benefited my students' communication of scientific concepts and allowed them to construct scientific knowledge based on their experiences within the science classroom. By focusing on inquiry activities, I was able to examine results that helped me teach science in a more interesting way for the students while maximizing their learning. "A growing body of academic research supports the use of project-based learning (PBL) in schools as a way to engage students, cut absenteeism, boost cooperative learning skills, and improve test scores" (Curtis, 2001).

At the onset of this study, I wanted to observe students within a scientific inquiry classroom to determine facilitation methodologies that would maximize their learning of science concepts. Furthermore, listening to their reasoning and dialogue during the inquiry activities allowed me to assess the students' understanding of the concepts rather than their simple execution of an experiment. I also planned to bring local scientists from the students' community into the classroom to work through the inquiry experiences with us. I realized the need to change the structure in which I taught science and reviewed my role as a director teacher in a constructivist classroom focused on enhancing the science inquiry experience.

Purpose of the Study

The purpose of this study was to explore how using an inquiry approach to teaching science affected students' ability to communicate about science concepts, their perceptions of science and scientists, and the role of the teacher. I wanted to examine perceptions of science and scientists before and after the study. I wanted to establish a scientific environment where children felt comfortable communicating about science concepts. Exciting young people about science was also a goal, and using science inquiry based on the ideals of constructivism was how I wanted to establish such an environment.

Question #1

How did science inquiry experiences affect students' ability to communicate about science concepts presented during the course of the study?

Question #2

How did working with local scientists affect students' perceptions of scientists?

Question #3

How did students' experiences with scientists affect their perceptions of science?

Question #4

How did science inquiry affect my role as a teacher?

Rationale for the Study

Reflecting upon the last four years of my teaching career, I have primarily taught science from a textbook. Vocabulary definitions were memorized, and experiments were driven by the text and done in the order provided by the curriculum. The trend I noticed during these four years was that students were able to perform well on a test given at the end of each chapter; however, when the same material was presented later in the

curriculum, the students' knowledge was minimal and consisted of an extremely basic knowledge of the concept, if anything at all. "Knowledge and skill in themselves do not guarantee understanding. People can acquire knowledge and routine skills without understanding their basis or when to use them" (Perkins, 1993, p. 1). Thus, my students demonstrated that this method of teaching science was not effective in teaching the higher-level thinking as defined in Bloom's Taxonomy. They were able to recite facts (sometimes) and possibly define, identify, or recall different science concepts, but they rarely demonstrated higher-level understanding of the science concepts that had been taught.

After assessing this learning situation, I was forced to analyze my teaching. As a new teacher, just being able to cover the material was sufficient. My knowledge of some science concepts was minimal, and I was uncomfortable in extending my lessons past the textbook's explanations. Reflecting on my practice, I realize how many "teachable moments" were missed over the course of those four years. The students seemed to enjoy different activities, and our discussions had potential to create some very interesting inquiry activities. If I had only listened more carefully to the students' discussions and questions and had been exposed to different types of inquiry methods, I could have taken advantage of those missed opportunities.

Scheduling also seemed to be problematic in the early years of my teaching experience. The curriculum did lend itself to a few experiments, but I found that with thirty-two students in my classroom, they were more of a hassle than a learning experience. Gathering the materials was all but impossible; if they were unavailable, I had to bear the expense. During these experiments, I did not listen to the conversations

that my students were having and was too focused on the teaching of the concept and the experiment's conclusion. Several times we rushed through the activity or experiment just to reach the "Aha!" at the conclusion, which several of my students seemingly failed to understand due to the nature of my instruction. I would further venture to say that my students perceived experiments not as vessels for understanding major science concepts but as fun activities after which they received something to eat.

Upon entering the Lockheed Martin/ UCF Academy (LMA), a new way of teaching science was presented through "Reflection on Instruction in Mathematics and Science." *Science Inquiry* was a term completely unfamiliar to me. After the first demonstration of a discrepant event, I found myself charged and excited about the prospect of presenting this idea to my students. Surely if I had such a reaction, they would, too. This intrigue was furthered by the content that I was discovering in "Problem Solving and Critical Thinking Skills" and through my teacher's union's professional development in Thinking Mathematics, which also used inquiry-based methods. Because of assignments given in class, I became enveloped in listening to the students. Their dialogue was so rich with inquiry about the science concepts being covered that I decided to approach teaching science in a different manner.

The constructivist view of teaching was also presented in class and provided a framework that sounded like my teaching style and ideals. I decided to employ the views of constructivism during my science lessons. As the LMA program proceeded, learning more about inquiry and different types of inquiry (for example, the 5 E method), as well as the need for a science curriculum that promotes scientific thinkers, led me to my thesis topic.

The entire first year of graduate studies was a precursor to the development of my thesis topic and provided ample opportunities for discovery and honing in on the different components of inquiry teaching and constructivism. During implementation of science inquiry activities into my established curriculum, one element that I noticed was the students' perception of science. They seemed to have unrealistic views of scientists and thought that successes in science were beyond their reach. Comments such as "I could never be a scientist; they're too smart" prevailed. This opinion prompted another component of my study, one that examined the perceptions students have about science and scientists. I would strive to implement a change in their perceptions.

Significance of the Study

The educational necessity is for teachers to create a generation of problem solvers who can work collaboratively through a situation that presents itself as challenging. "Today's workforce demands for high-performance employees who can plan, collaborate, and communicate. We also need to help all young people learn civic responsibility and master their new roles as global citizens" (Lemonick, p. 27). Using science inquiry, "Teachers can show students that science is a human activity: students can come to understand the processes and habits of mind associated with scientific work as they examine how scientists solve problems and build conceptual frameworks" (Bianchi & Colburn, 2000, p. 181). Between fourth and eighth grades, American students' achievement and understanding of complex science decline relative to their peers internationally (Linn et al., 2000).

America is again experiencing an increasing need for scientists. According to the February 13, 2006 issue of TIME magazine, "The quality of education in math and

science in elementary, middle and high schools has plummeted, leading to a drop in the number of students majoring in technical fields in college and graduate school.” The cover of the magazine boasted the title, “Is American Flunking Science” and suggested that experts in business and academia have been warning for decades that the United States is falling behind in science. President Bush even declared that US students should receive a “firm grounding in math and science” in his 2006 State of the Union speech.

One of the reasons for our lack of scientists could be the interest level in our students. Another aspect of science that I would like my students to comprehend is what a scientist is and how he or she works in the community. If their knowledge of science and scientists was more realistic and they were able to work side by side with local scientists, students’ interest and enthusiasm for science might be increased, and they might be motivated to continue their science education at higher levels. My intention was to expand my students’ perceptions of science and scientists, such that they would at least have a spark of interest in science as a career.

To further the situation at large, most students think of scientists as geniuses who live for science. In 1989, Jane Kahle did a study on the image of scientists as perceived by secondary students and compared her results with students’ perceptions from Norway, New Zealand, Australia, and the USA. “Although international results involving personality type vary somewhat by country, the basic finding is that children in several countries, including Australia, viewed science as harmful or evil and view scientists as eccentric or sinister men” (p.3). Few role models exist to promote the field of science to children. If I could provide role models from the community where the students live, their perception could possibly change to a more realistic view of scientists and the jobs

they encompass. More students would believe themselves capable of pursuing scientific careers, and most would view science as doable rather than abstract and non-relevant. More importantly, the students might realize that science is all around them in everything that they do, and they might again develop the intrinsic motivation of curiosity that existed when they were younger. It just has to be presented in such a way that their imaginations are captured again within the concepts.

For over 85 years, researchers have been calling for a reform in America's science classrooms. "We propose that more research is needed in the areas of teachers' beliefs, knowledge, and practices of inquiry-based science, as well as, student learning" (Keys & Bryan, 2001, pp. 631). Keys and Bryan further this proposition for teacher-developed inquiry-based instruction rather than researcher-developed inquiry activities. They suggest that more research of this nature might close the gap between the theory of science inquiry and the practice of it. "The painting of portraits of inquiry-in-action in a variety of diverse settings is greatly needed" (p. 637).

For the purpose of this study, learning for understanding (Huitt, W, 2004) has the following implications:

- demonstrating understanding using various methods (i.e. projects, discussion, illustrations, and demonstrations)
- understanding real-world application of science
- internalizing scientific processes, ability to ask more critical, testable questions
- using several resources to help oneself gather needed information.

The necessity to clarify the difference between knowing and understanding is present within a meaningful curriculum. “When a student knows something, the student can bring it forth upon recall; tell us the knowledge or demonstrate the skill” (Perkins, 1993, p. 2). To understand knowledge is not only to know it, but the ability to apply it in a variety of different contexts. “...Being able to perform in a variety of thought-demanding ways with the topic, for instance to: explain, muster evidence, find examples, generalize, apply concepts, analogize, represent in a new way, and so on” (Perkins, 1993, p. 3). I used Bloom’s Taxonomy as a guide to assess of students’ understanding of science concepts covered during the course of the study (Bloom, 1984). The definitions below provided clarification of terms used in this study.

Definitions

5E Learning Cycle Model: Developed by Bybee in 1989 (as cited in Coe, 2001) the inquiry model uses the following steps to engage students: Engagement (object, event, or question used to engage students), Exploration (objects and phenomena are explored), Explanation (students explain their understanding of concepts and processes), Elaboration (Activities allow students to apply concepts in contexts, and or build on or extend understanding and skill), and Evaluation (students assess their knowledge, skills, and abilities through activities that permit evaluation of student development and lesson effectiveness).

Bloom's taxonomy: A taxonomy, which identifies six types of knowledge: Knowledge, comprehension, application, analysis, synthesis, and evaluation.

Bloom was an educational expert who believed that learning involves, or should involve, moving from simple to more complex kinds of thinking (Huitt, W, 2004).

Constructivism: A theory of knowledge that is actively constructed by the learner. Furthermore, knowledge is not passively received from the environment. Coming to know is a process of adaptation based on and constantly modified by a learner's experience of the world. This definition was derived from VonGlaserfeld's (as cited in Jaworski, 2002).

Cooperative Learning: Consists of students working together, for one class period or several weeks, to achieve shared learning goals and complete specific tasks and assignments (Johnson, Johnson, & Holubec, 1998).

Draw A Scientist Test (DAST): The DAST was originally developed by Chambers (1983) as an open-ended projective test to detect children's perceptions of scientists. Chambers used seven standard image indicators to evaluate the images. The test has been expanded, standardized and revised by others (Mason, Kahle and Gardner, 1991) to include 11 standard images, alternative images and interview questions.

Inquiry: Following Staver & Bay (1987), in structured inquiry activities students are given a problem to solve, a method for solving the problem, and necessary materials, but not the expected outcomes. Students are to discover a relationship and generalize from the data collected. In guided inquiry, students must also figure out a method for solving the problem given. And in open inquiry, students must also formulate the

problem they will investigate. Open inquiry most closely mimics the actions of "real" scientists.

Project-Based Learning: a systematic teaching method that engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed products and tasks.

Scientist: A person learned in science and especially natural science : a scientific investigator (Merriam Webster Online Dictionary, 2005).

Sunshine State Standards: The State Board of Education approved the Sunshine State Standards in 1996, to provide expectations for student achievement in Florida. The Standards were written in seven subject areas, each divided into four separate grade clusters (PreK-2, 3-5, 6-8, and 9-12. In the subject areas of language arts, mathematics, science, and social studies, the Sunshine State Standards have been expanded to include Grade Level Expectations (Florida Department of Education, 2005).

Testable Question: Those questions students can answer on their own either through direct observation or by manipulating variables in an experimental setting (Pearce, 1999, p. 12).

Understand: Use of information within the three advanced hierarchies of Bloom's Taxonomy. Research has shown that students remember more when they have learned to handle the topic at the higher levels of the taxonomy (Huitt, W, 2004).

Overview

In chapter two, I reviewed the literature associated with constructivism, science inquiry, students' perceptions of science and scientists, and the role of a teacher in an inquiry classroom. Chapter three, entitled methodology, focused on the procedures for data collection, setting of the study, the participants, and the instruments used for data collection along with the data analysis. Chapter four discussed the results of the data analysis. Chapter five focused on the conclusions derived from the results of the data analysis. Recommendations were also made for use of constructivism to pursue an inquiry-based science curriculum, and some suggestions for professional development while pursuing the inquiry environment were given.

The next chapter provided research to support the use of scientific inquiry, community involvement and constructivism, along with research that questions the usage of these methods. Several authors who influenced the study are presented. My findings within this study coincided with their conclusions that scientific inquiry can be an effective tool for teaching a meaningful science curriculum. I chose to determine the use of scientific inquiry guided by constructivism as a workable practice within the science curriculum for my fourth grade classroom.

CHAPTER TWO: LITERATURE REVIEW

Inquiry is the central instructional strategy for teaching science as presented in the National Science Education Standards (National Research Council, 1996). Integral to this study and literature review is a discussion of inquiry and an explication of several related themes couched in a constructivist theoretical framework.

To review the literature that deals with the different ideas within this study, I began with research pertaining to constructivism. This research is followed by studies pertaining to science inquiry as a method to teach science concepts, followed by the perception and involvement of scientists from our community working in the classroom. Then the role of the teacher is addressed. Throughout the review, a balanced perspective of science inquiry is presented.

Constructivism

“If understanding a topic means building up performances of understanding around that topic, the mainstay of learning for understanding must be actual engagement in those performances” (Perkins, 1993, p. 3). These are the calls of constructivism, engaging students in performances that require hands-on approach to concepts. According to Alkove & McCarty (1992) the constructivism approach should have the following appearance: It should be student-centered as opposed to teacher-centered. Students, who take ownership of a subject by the challenge to articulate their personal goals for the learning in that area, work collaboratively in groups. Alternative assessments, such as anecdotal records, student produced work and process assessment,

are used. Educators team with other teachers in an effort to share ideas, frustrations, dreams, and moments of discovery. These ideas provide a glimpse into a constructivist classroom at its best.

According to Dewey (1910, p.127), “A slight amount of social philosophy and social insight reveals two principles continuously at work in all human institutions: one is toward specialization and consequent isolation, the other toward connection and interaction.” Isolation and Interaction are the two areas that every human being must work within in any given situation. The National Science Education Standards for teaching suggest, “Student understanding is actively constructed through individual and social processes. In the same way that scientists develop their knowledge and understanding as they seek answers to questions about the natural world, students develop an understanding of the natural world when they are actively engaged in scientific inquiry-alone and with others” (National Research Council, 1996). This standard is in direct correlation with Dewey’s philosophy about student learning and understanding. He professed that students’ positive attitudes in science need to be developed in the early years of life (1908, p.123). His plea was for the school system to recognize connections must be made, students develop into independent thinkers and they must consider themselves important to the world around them. These are some core concepts of constructivism.

Recent views of constructivism were inspired by the American concepts of pragmatism and experimentalism (Alkove & McCarty, 1992). Pragmatism is defined here as a set of beliefs held by an individual on which he builds the truth.

“Constructivists believe that determining truth requires a value judgment on the part of

the individual. As such, it cannot be objective or removed from the self' (Zahorik, 1997, p. 17).

Piaget, a forefather of constructivism believed that students construct knowledge based on their own experiences. They then assimilate this knowledge into their existing schema, or adjust their original schema to make sense of the new phenomenon (Piaget, 1964). Success, according to Piaget, is stated as:

Students' having enough understanding of a situation to attain the requisite ends in action, and understanding is successful mastery in thought of the same situation to the point of being able to solve the problem of the 'how' and the 'why' of the connections observed and applied in action (p. 218).

Furthermore, dissonance, or disequilibria is needed in order for learning to take place (Lumpe, 1995). Once the student solves the problem, or constructs a new understanding to fit into existing schemas, the disequilibria is resolved and learning has occurred.

As Jaworski (1996) states, "It [knowledge] does not discover an independent, pre-existing world outside the mind of the knower." "...Constructivists believe knowledge exists within the self and is constructed by individuals as they interact with themselves and with their environment" (Zahorik, 1997, p. 17). "The teachers' role should be to facilitate personal learning by establishing a community of learners, and by making it clear to the students that he or she is part of that community" (Zahorik, 1997, p. 18). "Concepts cannot simply be transferred from teacher to students, they must be conceived" (von Glaserfeld, 1995, p.5). Here the role of the teacher is transformed from

those traditional positivist behaviors (i.e. direct teaching, information giver) to a more facilitator-like role. The teacher provides the setting in which the learning will occur and the extent of inquiry that will be attempted, while guiding the students to construct the knowledge on their own. “For the constructivist, it is the meaning assigned to facts, rather than the facts themselves, that matters when we talk about knowledge, about knowing something” (Hinchey, 2004, p. 45).

Intertwined within constructivist beliefs is “...the importance of using authentic situations to develop rich understandings about scientific knowledge and how to design science tasks that prepare students to participate in social practices valued by the science community” (Lee & Songer, 2003, p. 924). The National Science Education Standards support a constructivist approach stating, “Student understanding is actively constructed through individual and social processes” (National Research Council, 1996, p. 28). “Activities in which students engage in problem-solving tasks-as individuals or in small groups – are critical to the growth of student constructions” (Zahorik, 1997, p. 32). These quotes provided the theoretical framework for the scientific inquiry thesis I am pursuing, because they link the concepts of inquiry so closely with those of constructivism. Inquiry is defined by Short & Burke (1996) as follows:

Instructionally, curriculum as inquiry means that instead of using the theme as an excuse to teach science, social studies, mathematics, reading, and writing, these knowledge systems and sign systems become tools for inquiry- exploring, finding, and researching students’ own questions. Curriculum does not focus on activities and books, but on inquiry (p. 98).

Scientific inquiry, discovery learning, and project-based learning are all closely related and formed from the constructivist tenants. “The premise of constructivism implies that the knowledge students construct on their own, for example, is more valuable than the knowledge modeled for them; told to them; or shown, demonstrated, or explained to them by a teacher” (Loveless, 1998, p. 285). The ideals of constructivism coincide with those of John Dewey, who also suggested that children make meaning and acquire knowledge through authentic learning where they discover. “This process is natural because all children in a classroom work at his or her level. Children working on projects are empowered to make decisions about their learning and whether they will lead or follow on any given day” (Diffily, 2002, p. 42).

This remaining review of literature will focus on three areas; scientific inquiry (also identified as project-based learning), students’ perception of scientists and the role of the teacher within a constructivist classroom.

Scientific Inquiry & Project Based Learning

Sputnik and the era generated by Russia’s success sent a serious call to change the way science is taught in schools in America. “Crises in Science Education” an article put together in 1979, by representatives of 28 different programs and four groups of over 150 science educators, composed a list of priorities for science reform. After reviewing the priorities, a survey was issued to rank the priorities from critical need, a definite need, or a low-priority need. Kahle (1982) recommended, after reviewing results of the survey that “New directions for science education are needed” (p. 528). To further this idea, Yager and Yager (1985) found, “The NAEP affective results and the related follow-up studies all suggest that typical science instruction as viewed by large representative

samples of third, seventh, and eleventh grade students is in need of serious attention” (p. 357). Yet again, the Journal of Research in Science Teaching Preface to its August 2001 volume reiterated its emphasis on reform. Everywhere you look; calls for reforming the way we teach science are echoed. All of these signs point to use of science inquiry as a means to teach science concepts effectively.

Diane Curtis, researcher for the George Lucas Education Foundation has found that, “A growing body of academic research supports the use of project-based learning in schools as a way to engage students, cut absenteeism, boost cooperative learning skills, and improve test scores” (2001). PBL fosters problem-solving skills that students need in the real world. “Project-based learning, or service learning, in which students volunteer their time, effort, and skills to a social cause can be an effective method of learning for a variety of students, including students with disabilities” (as cited in Carr, 2000, p. 42).

This method would provide a reliable teaching method for all types of students.

Scientific inquiry will not only inspire a meaningful learning experience, but will also allow students problem solving strategies for other curricula and life as well. Within the preface, Charles Anderson, the co-editor, says, “When we promote “science as inquiry” as a national goal, we aspire to influence the ways that our citizens go about making sense of the world around them” (Anderson, p. 629).

In a study done by Druger and Lederman (1985) students’ conceptions of the nature of science exhibited “successful change” when learning occurred in classrooms that had these common characteristics: frequent inquiry oriented questioning, problem solving, teacher-student interactions, more reference to the developmental, testable, and moral and ethical aspect of scientific knowledge. Other studies by Haukoos and Penick

(1983) have also shown that a “discovery” approach to science yields gains in students’ knowledge of the nature of science.

Another aspect that will be added to the classroom to enhance scientific inquiry is technology. “Technology enables Project Based Learning” (Solomon, 2003, p. 21).

According to Solomon (2003):

E-mail, electronic mailing lists, forums, and other online applications facilitate communication and collaboration with the world outside the classroom. The Web provides access to museums, libraries, and remote physical locations for research. Students can create electronic compositions of art, music, or text collaboratively; participate in a simulation or virtual world; and work together to accomplish a real task or to improve global understanding. And all work can be published on the Web for review by real audiences, not just a single teacher, class, or school (p. 22).

As Solomon references, there are several ways in which technology enhances project- based learning. This multimedia is an available and usable tool for all different learning types. Carr (2000, p. 41) found that, “The combination of text, sound, graphics, and motion video arranged in non-linear, linked nodes in hypermedia allows learners to efficiently deal with large and disparate sources of knowledge.” “Computer tools can make abstract concepts manipulability and allow students to act like scientists, learning content in the context of real world problems” (Stoddart et al., 2000, p. 1221). The use of technology during scientific inquiry will teach the children skills they need to function in today’s career world as well as allow them to investigate ideas like scientists. Computers also provide the ability to link students to the world outside the classroom. They can

access museums, scientists, and research topics with the click of a mouse. This is why technology serves as a vital role in project-based inquiry science classrooms.

Another theory suggests that inquiry projects might lend themselves to more involvement and internalization if they were connected to the students' lives directly. "Projects should have a connection to the real -world by focusing on issues that affect students' lives or communities, and by using realistic methods such as polling, researching, and experimenting" (Solomon, 2003, p. 22). Solomon goes on to note that, "the real-world focus of PBL activities is central to the process. When students understand that their work is ultimately valuable as a real problem that needs solving, or a project that will impact others, they're motivated to work hard." When students are benefiting their own community they are held to a higher standard. Using the science concepts, such as the water cycle, to link the students to the importance of conserving water can be a powerful learning gain. According to Solomon, Ed Gragert, director of EARN, which offers Project-Based Learning projects that address local, national, and global issues:

Collaboration, interactivity, and a clear outcome that improves the quality of life on the planet really speaks to kids. By demonstrating that they can make a difference in even a single life, students are motivated and empowered to carry their experiences into lifelong community and global service," (p. 22).

Any opportunity to create a bridge between the students' lives and the science curriculum will help promote the scientific inquiry process.

Some criticism for constructivism and project-based science exists. There are some very legitimate criticisms that constructivism faces. "A teacher does not promote

understanding by permitting students' constructions to stand even though they clash with experts' construction" (Zahorik, 1997, p. 31). Some experts argue that allowing students to construct their own interpretations of scientific knowledge will cause confusion and misconceptions to occur. As a teacher, it is our job to teach students correct conceptions that have been proven, and to ensure their construction of ideas fits within the proven concepts. Therefore, if a student is constructing misconceptions the teacher must intervene. "...It is dangerous to ignore the concepts, conventions, and processes that are essential to the maintenance of our culture or to wait for them to emerge over time through random experiences" (Zahorik, 1997, p. 31). The teacher's job expands to assure a balance of conceptual learning that blends into the students' conceptions and constructions of science. If an educator observes a student is constructing their knowledge incorrectly (assessment should be ongoing) then it is their job to intervene and steer the student to the correct understanding of the concept being learned. Phillips argues the idea of "misconceptions" stating, "Moreover, it is clear from von Glaserfeld's perspective that everyone studying a field like science has his or her own set of conceptions and preconceptions that influences the course of subsequent learning; teachers should drop the fashionable but misleading talk of student 'misconceptions,' for this implies that there is a standard set of 'correct' conceptions that all learners should have" (2005, p. 10).

Although I understand both viewpoints, I do think it is important to intervene if a student is constructing misconceptions based on their experiences. A teachable moment would hopefully occur where we could observe the steps the student followed to come to their misconception and decide where the misconception occurred. Rather than continue

believing the misconception, the correct concept would be further ingrained because the students work would still be valued and their own. The affect that in-depth look into the process would have on the student's understanding needs further investigation.

Furthermore, Klahr and Nigam (2004) cite studies that have found science to be more effective when taught through direct teaching while pointing out that most of what we know about science, and furthermore, most of what scientists know, was taught to us by someone (p. 661). Through their own empirical study of path independent transfer, they found students who learned via direct instruction learned and transferred information equally as well as those who learned via inquiry or discovery learning. They further implied that, "...these results replicate other studies in which direct instruction was clearly superior to discovery learning in facilitating children's acquisition of Control of Variables Strategies" (Klahr & Nigam, 2004, p. 666). Obviously more extensive research needs to be done over an extended period of time that would demonstrate retention and transfer of knowledge learned via direct instruction, as well as inquiry, to validate claims from either stance.

Furthermore, constructivism can promote intellectual development, scientific inquiry, and the development of problem solving skills. These are lifelong skills that would need to be tested over an extremely lengthy period of time to truly establish validity. Further study is needed to come to a stable conclusion on which method is more effective for which variable. However, noting each student is an individual would help us to remember that different strategies will benefit different students at any given time.

To further my assumption, Keys and Bryan (2001) assert that more data on teacher beliefs, knowledge, practices, and student learning from teacher-designed inquiry

instruction is needed. Such reform has been prevalent for many many years, however Keys and Bryan suggest that, “Only when the voices of researchers are in resonance with the voices of teachers can we begin to create harmonized reform-based instruction that is enduring” (p. 642). Until this happens, there will be more research on theories, and less implementation of these theories.

Perceptions of Science and Scientists

Kahle (1998) found that an individual’s perceptions of scientists are one aspect of attitudes toward science and that this may have an impact on the attention given to the study or teaching of science (as cited in Finson, 2002). “In general, students’ impersonal images of scientists were very positive, yet their personal perceptions were negative...when the question concerned science as a career choice for themselves or a close family member, the responses were overwhelmingly negative” (Purbrick, 1997, p. 60). Where are these stereotypic images prevailing? At what age does gender bias begin? Carlo Parravano, director of the Merck Institute for Science Education, suggests that, “By fourth grade, we squash that curiosity with the way we teach science,” when commenting about children’s love of exploration of the natural world. (Keegan, 2006, p.26).

“Despite the efforts of science curriculum developers to depict scientists as people from all walks of life and a variety of racial and ethnic backgrounds, students generally perceive scientists as white males. Many also have a narrow view of how scientists work and see scientists as individuals who work alone in a laboratory” (Barman, 1996, p.30). An international study done by Kahle (1989) found that, “...Children in several countries,

including Australia, view science as harmful or evil and view scientists as eccentric or sinister men.” “One of the teacher’s primary resources is the textbook, and it is probable that teachers would find it easier to present a science free of gender bias if textbooks themselves were gender fair” (Elgar, 2004, p. 879).

“Consequently, the question has been raised, how can teachers change children’s images of science and scientists?” (Purbrick, 1997, p.61). Kahle (1989) encourages teachers to find a way to teach science in such a way that it appeals to both girls and boys. “Teachers cannot escape the responsibility to present science as equally appropriate for girls and boys” (as cited in Elgar, 2004, p. 876). Furthermore, all students need to perceive science as a doable curriculum, understanding that the world around them is science. “If instruction [in science] were improved and if the affective outcomes could be improved, more persons might elect to pursue formal study of science with more interest, understanding, and commitment than the current system produced” (Yager & Yager, 1985, p. 357). This statement was made after reviewing the results of a NAEP study that looked at third, seventh and eleventh graders’ perceptions of scientists. These perceptions showed that third grade students are more likely to see being a scientist as fun than their older counterparts. Somewhere, their general perceptions are faltering. “Significant numbers of students perceive science careers as lonely; over half of the students at all grade levels have such perceptions” (Yager & Yager, 1985, p. 355). Teaching science through inquiry with scientists from the students’ community partnering with the teacher might establish a strong motivation towards science in fourth grade that would propel the student towards an education in science. Working with

scientists during this study might instill a perception of science and scientists that is more realistic and inspire children to continue their curiosity and scientific drive.

Role of the Teacher

“A successful science teacher at all levels may need to understand the basic features of science as a human enterprise better than many practicing scientists and/or college science instructors” (Yager & Yager, 1985, p.357). As cited in Von Secker and Lissitz (1999), “The Standards call for pedagogical shift from a teacher-centered to a student-centered instructional paradigm. Whereas teacher-centered instructional strategies such as large-group instruction, recitation, drill, and opportunities for controlled independent practice are successful for tasks that demand rote memorization, they have not been shown to be effective for teaching higher-order thinking and problem solving (Darling-Hammond, 1996). The Standards recommend a student-centered instructional environment that engages students in socially interactive scientific inquiry and facilitates lifelong learning” (p. 1110). “At all stages of inquiry, teachers guide, focus, challenge, and encourage student learning” (National Research Council, 1996). I will no longer be the director of knowledge, but the facilitator. Orchestrating the students in collaborative groups, asking critical questions to encourage discourse, and making sure each student is challenged on their level while engaged in learning the overall science concept at large is the main focus of a teacher as facilitator role in PBL. Project-based learning places the most emphasis on topics of everyday concern, which, through the teachers’ guidance, enables students to explore and solve problems together with their peers (Lee & Tsai, 2004, p. 31).

“Teachers who were subject to a didactic, knowledge-based approach during their own experiences as students, who interpret science teaching as transmission of facts, and who feel that tight control is a necessary feature of teaching, are unlikely to invite students’ questions” (Chin et al., 2002, p. 522). Crawford extends this rationale by saying, “...an inquiry-based classroom requires taking on a myriad of roles, roles that demand a high level of expertise” (p. 932). To help with these roles, an educator can look to the abounding community of experts available to them. “Community members possess an immeasurable fountain of information and leadership skills” (Preuss, 2002, p. 17). These experts in the field can supplement a teacher’s content knowledge of a specific subject area of science. Involving professionals with the inquiry process will help alleviate teacher uncertainties, which are a deterrent for many teachers from utilizing the inquiry process. Not only will these scientists serve as a non-stereotypical view of scientists, they will also connect the inquiry activities to the students’ community. This is the type of teaching that John Dewey referred to when he spoke of real-world experiences, ones that have meaning to the students who are encouraged to formulate the questions.

Another reason given for a change in the role of the teacher as one who nurtures science inquiry is noted in Yager & Yager’s (1985) study of students’ perceptions in third, seventh, and eleventh grade. Twenty-three items from four affective categories, i.e. Science Teachers, Science Classes, Usefulness of Science Study, and Perceptions of Being a Scientist, and the results of these items showed that beginning in third grade, only about 50% of students feel like their science teachers value their questioning. This number decreases as the students get older. Approximately 60% of third graders viewed

their science class as fun, with this percentage decreasing in the higher grade levels. Over 80% of the third graders found science to be interesting, while about 40% felt the same in eleventh grade. The most disappointing statistic noted was that science only makes about 55% of third graders feel successful, diminishing to only 30% in eleventh graders. Furthermore, third grade students do not feel like their teachers like science. The study suggests that “There is little evidence that school science affects student attitude about science, science classes, science teachers, and science careers in any positive ways. There is some evidence that the school produced negative views...” (Yager & Yager, 1985, p.356). As a teacher, my primary job is to teach students to be successful and elevate attitudes towards continuing education. If our science programs are being viewed as negative, we are not doing our job effectively.

Chapter two has reviewed literature that supports the framework of this study, constructivism. It has provided support for science inquiry as a method for teaching science in such a way that communication depicting an understanding of science concepts takes place in an elementary classroom, and discusses findings that students’ perceptions of scientists and science are stereotypical and a need to change into a more realistic view. I also examined the role of the teacher in the inquiry environment. Educators must exhibit certain behaviors to nurture an inquiry atmosphere and suggestions found in previous research have been investigated.

Chapter three examined the school context, the design of the study, and the different methods of data collection. It provided the setting in which the study was conducted and the manner it was conducted.

CHAPTER THREE: METHODOLOGY

The purpose of this study was to examine students' ability to communicate about scientific concepts presented in an inquiry environment, students' perceptions of science and scientists, and the role of the teacher within an inquiry environment. The research methods chosen encompassed a variety of qualitative strategies including field notes, videotapes, observations, interviews, Draw A Scientist Test (DAST), Discovery Logs, and a pre and post questionnaire found in Nurturing Inquiry (Pearce, 1999). The design of the study was presented in this chapter, including the school and classroom setting. The instruments I used to collect data, and analysis of the information gathered during the course of the twenty week study were presented.

Design of Study

The research method used during the course of this study was action research. Action research allows the researcher an in-depth look at the population that is being used during the study. For educators, it provides a means of assessment that is invaluable. It allowed the educator to reflect on their own practices and what needs to change and stay the same. Most of all, it encourages growth. "Action research serves an important role in improving schools and schooling" (Gay & Airasian, 2003, p. 169). Action research was the chosen research method of this study because of its beneficial use for educators in understanding and improving their practice.

Prior to the commencement of the study, an IRB was submitted and permission to carry out the study was granted. The principal gave his approval, and the parents also provided their consent. Furthermore, each student gave their assent verbally. The

consents and approval met the requirements established by the University of Central Florida's IRB Office.

Qualitative and quantitative data were used during this study. The questionnaire, and pre and post DAST provided quantitative data, while teacher made discovery logs, interviews, videotapes, observations and field notes provided qualitative data. The qualitative approach provided an in-depth, rich collection of ideas, thoughts, attitudes, and reactions of the students participating in the study during science inquiry activities with the teacher researcher and volunteer scientists.

To enhance the validity of the study and reduce bias, several strategies were used. The study was extended for a longer period of time than originally planned to obtain additional data and compare it to earlier data. A concerted effort was made to gain the trust of the students participating. Verbatim accounts of interviews and observations were used based on videos. Also, the data was corroborated using triangulation. "Researchers triangulate by using different data sources to confirm one another, as when an interview, related documents, and recollections of other participants produce the same descriptions of an event" (Gay & Aiasian, 2003). The data were compared to distinguish repeating themes that emerged from the variety of sources.

Setting

School Setting

The school utilized in this study was located in a rural area in Central Florida. Sixty-eight percent of the enrollment received free or reduced lunches. The school served a rural population that was 94.75% Caucasian, 0.57% African American, 3.56% Hispanic, 0.14% Native American, and 1% multiracial. It was a charter school and

received the school grade of A for the last four years and also completed Adequate Year's Progress (AYP). Each year their Florida Comprehensive Assessment Test (FCAT) scores are among the top in the county, despite the demographics discussed above.

Classroom Setting

The accessible population was an accurate reflection of the school's demographics listed above, and they all participated in the study. The classroom contained fourteen students, eight males and six females. The students were assigned to my class by the administration. Of the fourteen students, eight were labeled Learning Disability (LD) or were in the process of being tested to determine the type of LD the student has. Their learning disabilities included mathematics, reading, speech, and other health impaired. Two of the LD students were also labeled Emotionally Handicapped. Of the remaining six students, one was a retention. The five remaining students were of average academic ability and perform on grade level. The students' ages ranged from nine to eleven.

Instruments of Data Collection

Several instruments were used to assist with gathering information that would answer the research questions posed in chapter one. The Draw a Scientist Test (DAST), discovery logs, interviews, questionnaires, field notes, and videotapes were the instruments chosen. The instruments' purposes and justification for use are described in the following sections of this chapter.

Draw A Scientist Test (DAST)

The DAST was created by Chambers (1983). Since this time it has become public domain. “The DAST provides an easy way to assess if students hold stereotypic images of scientists” (Kahle, 1989, p.4). The DAST was selected because its ease of use for children. It was used to determine the students’ perceptions of scientists at the onset of the study, and again at the conclusion to determine whether the perceptions have been affected through exposure to scientists during the study. “Because the DAST requires no reading or writing, it minimizes the possibility of ‘socially desirable’ responses” (Kahle, 1989, p. 3). To minimize concern about the validity of the DAST, Schibeci and Sorensen (1983) recommend using an interview along with the DAST to determine what the student is really depicting and found the DAST a reliable method for assessing global images of scientists (Sumrall, 1995). The participants in the study drew the scientists and wrote a short description on the back to tell what was depicted in the picture.

Student Questionnaire

The questionnaire was obtained from Nurturing Inquiry (Pearce, 1999, p. 17, figure 2.4). It was used to determine students’ past experiences with science and determine any questions that they still have pertaining to the concepts previously covered at the beginning of the study. Another function of the questionnaire was to determine the students ability to communicate about science concepts learned previously. To conclude the study, this questionnaire was completed again with the focus being on their ability to communicate logical questions based on the concepts covered during the course of the study. The two questionnaires were compared to determine emergent themes.

Permission to use the questionnaire was granted and can be found in Appendix B. To

enhance validity of interpretations, I conducted interviews with the students to provide clarity to any areas of confusion found within their questionnaires.

Discovery Logs

Discovery Logs were used for several of the inquiry activities and served as a means to design the experiment and discuss the outcomes. This process allowed the students to construct and conceive the knowledge, rather than having it transferred to them by me, the teacher (von Glaserfeld, 1995). They were constructed by the teacher-researcher and were based on different inquiry method designs. Each log required the students to establish a question (if it was not established for them), list steps, draw a picture, hypothesize, list predictions, record outcomes, and discuss science concepts learned from inquiry activity.

To establish validity, a rubric was used to assess the discovery logs, and some were not given a grade. The discovery logs were also reviewed by four colleagues for readability and clarity. The students became more familiar with the processes on the logs as the study progressed and their ability to understand a rubric and its uses developed as well. Because of the nature of the inquiry activities, the students were not graded on a specific outcome, rather the steps taken to reach an outcome and a general knowledge of the larger concept that was being manipulated.

Qualitative Methods of Data Collection

Several methods of data collection were used during the course of this study. The qualitative nature of action research called for several observational type sources of collection to provide rich details and descriptions within the research study. These methods included videotaped discussions, interviews, reflections, and field notes. The

remainder of this section will discuss how these methods were used within the study and aligned with emergent themes presented within the analysis of the data.

Videotaped Discussions

Discussions and inquiry lessons were videotaped to capture student dialogue and teacher/student interactions during science day. These videotaped allowed me to copy dialogue verbatim to ensure validity of discussions. They also allowed me to view my interactions with the participants and focus on how those interactions changed throughout the course of the study.

Field Notes

Field notes were used during the course of this study to collect data during the inquiry activities. I visited each group periodically and record their dialogue. The anecdotal records allowed me to remember these conversations when the videotape was focusing elsewhere. These discussions revealed students' perceptions of the science inquiry activity and provided their reasoning behind the hypothesis and predicted outcomes. Students' understandings of the concepts were also gathered through the field notes.

Interviews

Interviews were used whenever clarity was needed. During the DAST, some students drew figures whose gender was undistinguishable or figures that were doing something, but what they were doing was questionable. Interviews were conducted to ensure validity, and decrease teacher researcher imposed stereotypical images due to assumptions. Interviews were also used when a student's written response did not provide enough description to understand their answer. I would call the students to my

desk and have informal interviews, recording their answers within the log or assessment where they were working. I was able to refer to these interviews when assessing the pre and post DAST, pre and post questionnaires, and the teacher made assessments.

Teacher Reflections

At the end of each science inquiry activity, I would reflect on the day's experiences, successes, and failures. The reflections revealed student led discussions, inquiry activities independent of direct teacher instruction, and students leading the curriculum sequence. These trends support the emergent theme for research question number three and provided triangulation of the data collection methods to support the role of the teacher changing during the course of the study. They also depicted student discussions and experiences that supported the emergent theme for research question two that students' perceptions of science and scientists had changed.

Procedure

Students in my science class received two hours and forty-five minutes of instruction a week. Instruction occurred on Wednesday, otherwise known as "Science Day". The unit of study for this research was "The World Around Us" and we focused in on the following ideas: Ecosystems, Water, Soil, and Matter. The students' inquiries guided our course of study. The National Science Education Standards (NSES) (National Research Council, 1996) guided two aspects of the study, the role of the teacher and the science content. The NSES that were used can be found in Appendix D. These standards served as a model for me when implementing the inquiry activities. They helped me transition from a more traditional role to the type of facilitator type instructor required for an inquiry environment. The Sunshine State Standards used to help guide

learned content were Strand A: The Nature of Matter, Strand B: Energy, Strand D: Processes that Shape the Earth, Strand G: How Living Things Interact with Their Environment, and Strand H: The Nature of Science. The benchmarks utilized in the study can be found in Appendix D.

The content of the study was derived from several different places. The use of the adopted text, Harcourt Science (2000), was utilized as a resource for experiments or lessons, as well as the Internet and other teachers on the fourth grade team. The objectives for each standard along with their associated level according to Bloom's Taxonomy, were as follows:

Nature of Matter

1. Define density (Knowledge)
2. Explain how to measure density (Comprehension)
3. Compute the density of an object using $D=M/V$ (Application)
4. Categorize items that are buoyant from those that are not using conclusions from previous testing (Analysis)
5. Justify hypothesis (Evaluation)

Energy

1. Categorize bones found in owl pellet (Analyze)
2. Construct owl food chain from bones (Application)
3. Create another food chain based on knowledge gained from owl food chain (Synthesis)
4. Justify food chain based on research (Evaluation)

Processes that Shape the Earth

1. Explain the water cycle (Comprehension)
2. Illustrate and Label the parts of the water cycle (Knowledge & Comprehension)
3. Hypothesize how many days it will take for $\frac{1}{4}$ cup to evaporate (Synthesis)
4. Define "Testable Question" (Knowledge)

How Living Things Interact with Their Environment

1. Define ecosystem, elements, terrarium, model, system, community & population (Knowledge)
2. Create a terrarium with knowledge gained previously about soil, etc. (Synthesis)
3. Create a hypothesis (Synthesis)
4. Justify the outcome based on variables (Evaluation)
5. Demonstrate knowledge of scientific method (Application)

Nature of Science

1. Develop testable hypothesis within different science concepts (Synthesis)
2. Justify results of experiments (Evaluation)
3. Categorize, compare, and contrast scientific knowledge with peers (Application)
4. Analyze peer results (Analysis)

Scientists Within the Classroom

Five scientists from the students' community were invited to come to visit our classroom and present an inquiry lesson. An Environmental scientist from the St. John's River Management District, two scientists (one Senior Environmental Biologist and another a Biologist) from LPG Environmental, an environmental scientist from Lake County Environmental Services, and another scientist from Lake Soil and Water Conservation District volunteered to work with the students. The first scientist who visited taught the students about the Florida Aquifer, and provided two models. The first model depicted the different types of waste that can run into watersheds and eventually into the water in our aquifer and the second was of the aquifer. Students participated in her presentation and she presented it using a constructivist approach, questioning the students rather than giving the knowledge. She engaged the students with questions rather than providing answers and lecturing. She was also aware of the study I was conducting and discussed several scientists she works with and their jobs within the St. John's River Management District.

She was followed by two biologists from LPG Environmental. These scientists developed an inquiry lesson for the students to participate in. They guided the students through a water purification contraption. This inquiry activity provided their first true experience with open inquiry, and allowed the students to create their own water cleaning device from whichever materials they chose. They had to justify their reasoning for choosing different materials, make a diagram of their contraption on their discovery log, and predict outcomes before they were able to build and test their contraption. Only one group was successful in cleaning the water. This spurred a class competition and the students chose to go home and create another contraption based on what they learned from the day's inquiry activity. These two scientists also worked with the students through email communication. If the students were working on an inquiry project and needed some help, they were able to email these two scientists and their reply would refer the students to a website that could offer some assistance.

The next scientist presented a lesson on waste management and Lake County's current disposal systems. She did more of a lecture presentation, however she emphasized scientists' jobs within the waste management offices and also indicated that scientists are also mathematicians through a mathematics activity she used to hook the students in the beginning of the lesson. She was also aware of the second research question of the study, and therefore spoke about the different jobs scientists do for Lake County Environmental Services.

The last scientist who visited presented a lesson on soil. She brought in six different types of soils and had the students observe the soil with hand lenses and manipulate it to determine the properties of the different types of soils. She then inquired

which soils would be best for different needs and discussed the types of soil found in Florida. The students were able to identify with this lesson based on their experience with the volunteer biologists. When they visited, they introduced themselves and told the students what their jobs entailed. One aspect is wetland delineation and they showed the students a soil tester they used. The students transferred that knowledge to the final scientist's visit and talked about using the tool with the other scientists.

Through the scientists' interaction with the students during the course of the study, the students were exposed to real-world images of science and scientists. Using field notes, discussions, videotapes, and the pre and post DAST, I determined whether a change in their perceptions took place.

Data Analysis

The DAST was given as a pre and post test. The tests were examined for changes in students' perceptions of scientists from the beginning of the study to the conclusion. Emphasis was placed on whether stereotypical descriptions we present, such as eccentric appearance, lab coat, white male, sinister implications, glasses, and more. The reflections allowed me to return to each day's successes and failures and plan different areas of improvement that were assessed during the inquiry activities. The reflections also showed growth in my role as a facilitator. I began to plan based on the students' inquiries and needs and used resources that had never been explored before. They revealed the students' lack of reliance on me as the giver of knowledge during the course of the study. Our comfort (the students' and mine) in the inquiry environment became evident within the reflections as well.

The student questionnaire (pre and post) allowed me to compare students' knowledge of concepts studied at the beginning of the study to those at the end. The questionnaires showed that the students understood more scientific concepts than initially, and that they know what a testable question is and how to produce one. They also provided a window into whether there are still any questions regarding the concepts that we explored. These questionnaires served as a guide for the fifth grade teachers to use when planning their curriculum.

The videotapes, teacher reflections, and field notes were used to document any changes in my practice. These qualitative methods of data collection helped me to listen and document student conversations and assess whether changes in their participation and conversation about the inquiry science experiences took place. As mentioned above, the tapes and field notes provided an in-depth observable look into the study and allowed me to assess the multiple areas of the questions being pursued by the participants in the study. My personal reflections provided insights into my own practice and how I was feeling or interpreting different actions throughout the course of the study.

Triangulation across methods and sources of data increased the trustworthiness and credibility of the research. All of the interviews, field notes, and videotapes are repeated verbatim and member checks of teacher made discovery logs have also established credibility and trustworthiness of the study.

Summary

Several qualitative methods were used to collect and analyze data during the course of this study. Some quantitative data were also analyzed. The data collection instruments allowed invaluable insights into the students' perceptions of scientists and

how they have changed over the course of the study. They also allowed me to assess whether an improvement in the students' ability to communicate about science concepts learned has occurred and to observe how my teaching strategies have changed from direct instructor to facilitator over time. In chapter four data analysis was presented and emergent themes were discussed.

CHAPTER FOUR : DATA ANALYSIS

This action research study focused on students' understanding of scientific concepts, their perceptions of science and scientists, and the role of the teacher in an inquiry environment. The fourteen students who voluntarily participated in the study completed several inquiry activities over the course of twenty weeks. I collected data and utilized it to determine emerging themes that aligned with the questions presented in chapter one. Field notes, observations, discovery logs, interviews, pre and post questionnaires and the DAST were the sources for triangulation of inferences made in this study. The triangulation of multiple sources of data increased the validity of the results of the study. To answer each research question, data were triangulated and aligned to support the emergent themes.

A Typical Science Class

During a typical science day for the duration of this study students had inquiry experiences with the classroom teacher and invited scientists. Science was taught on Wednesday each week from 9:30AM until 1:45PM. First, a typical day with the classroom teacher was discussed. Materials were passed out to students to invoke critical thoughts and questioning. Students worked in cooperative groups to investigate and pose questions that the teacher used to facilitate student learning of the science concepts. For example, to initiate learning the concept of food chains, I passed out packaged owl pellets, skewers and toothpicks, and rubber gloves to the groups, which consisted of three or four students each. The students observed the object wrapped in foil and hypothesized what it contained. Then they opened the owl pellet and were instructed to explore the contents using their materials and develop questions and inferences as to the content's

identity. Another brainstorming session was conducted after students had explored and several suggestions, such as, “It’s poop,” and “It’s throw-up,” were given. All of the groups noticed the bones that were inside the pellets, which helped them figure out that the object was from an animal that eats other animals. I asked the groups what animal they thought it was from and after some initial nonsensical guesses, one group suggested a small animal because of the size of the object. From this inference, I told them it was an owl, and that the object was not feces (as some had suggested) but rather the regurgitated bones. This opened another discussion about why the bones were not swallowed. The students accessed prior knowledge based on their experiences eating bones, or lack thereof. At this point, the students were given a bone identification chart. They dug through the pellets and sorted the bones. Then, they used the bones to reconstruct a skeleton of the prey.

At the conclusion of the activity, we discussed how the owl and its prey form a food chain. We then broadened the concept of food chains to include the animals that eat owls and the plants that prey of owls eat. This activity was followed by an outdoor game to reiterate the idea of the circle of life the food chain represents and why each part is intricate and needed. At the end of each unit an assessment developed by the teacher researcher would be given, based on the discussions and outcomes of the inquiry activities to gauge the inquiry’s effectiveness. For the inquiry activity discussed above, the students were given a different animal and asked to construct a food chain. Also, they were given a scenario where one animal was removed from the food chain and asked to discuss the consequences.

Four volunteer scientists visited the class throughout the study. During their visits, the invited scientists all used different inquiry techniques, but the focus was on getting students to inquire into the natural world. For example, two scientists presented lessons that were pre-constructed. An environmental scientist from the St. Johns River Management District presented a lesson on Florida's aquifer. She brought in two models, one of the aquifer, and another of a typical town. She had volunteers come and sprinkle fertilizer on one lawn, another student sprinkle soap from washing their vehicle, and so forth. Then, she questioned the students as to which type of rain was more harmful, heavy or light? The students offered answers. This was followed by a demonstration of a light rain, which caused minimal runoff into lakes and streams, and then a heavy rain that caused all of the remaining pollutants that had been added to the model previously, to swiftly run into the lakes and streams. This was followed by a demonstration of how the aquifer works to clean and recycle our groundwater. Then she discussed different ways students can conserve water and the reason conservation is required of all citizens.

Two Environmental Scientists followed the first environmental scientist. These two scientists work in the field of Biology and were from Florida Land Planner Group (LPG) Environmental. They knew that the first environmental scientist had presented a lesson on the aquifer and how it cleans the water. They used open inquiry and had the students construct a contraption to clean water that had been mixed with one cup of blue tempera paint. They were given no instructions as to how the materials should be used and relied on their prior knowledge of the aquifer that had been constructed two weeks prior to the investigation. The students had to document their inquiry, recording materials they used, drawing a picture of their contraption, and finally putting it together.

Then, one cup of the water was poured into their contraptions. At the end of every inquiry a discussion was conducted, focusing on their experiences. This particular session focused on the materials the students used that worked, why they worked, and what other materials might have been effective.

Science inquiry was a new method of teaching science to these students. Evidence of this was clear in our discussions about science topics and their past experiences with science. From the onset of the study, the students were enthusiastic about “Science Day”. I was very intrigued to determine the effectiveness of the inquiry activities on the students’ ability to communicate about science concepts presented during the study and how they viewed science in the real world. Also interesting to me was the role I would play in this new inquiry environment and how it would affect my teaching habits.

Student Communication About Science Concepts

Research Question #1: How did science inquiry experiences affect students’ ability to communicate about science concepts presented during the course of the study?

To investigate the students’ ability to communicate various science concepts that had been taught in previous years, a student questionnaire was given at the onset of the study and again at the conclusion. The questionnaire was obtained from Nurturing Inquiry (Pearce, 1999) (Appendix C). The questionnaire has four questions pertaining to science topics previously learned and eight opportunities for students to write questions that they still have based on their recollection of the topics. Student responses were

scored based on the number of questions that were related to a scientific concept rather than nonsense questions that were more humorous.

No prompting of past science concepts was offered, as a way to ensure their responses would be an indication of what they recall. Their responses were confused and lacked testable questions. On the Pearce survey that was aforesated, students were given the opportunity to respond with up to 112 questions. However, only ten questions were asked collectively on the initial pre-questionnaire. The ten questions were posed by six of the fourteen students. Questions such as the following abounded: “What would happen if the planets exploded?” “What if we didn’t have any air on Earth?” and “What if Mars was green and maybe an alien ate it?” These questions were not focused on science concepts or science inquiry but were more nonsensical and questions that they already knew the answer to.

The students were confused and did not react well when taking the questionnaire, which was evident within their responses. “I don’t get it!” and “What does this mean?” were cries heard continuously. I hesitated to provide any suggestions as a means of preserving their thoughts and not influencing their answers. Also evident was that they were not able to ask thought provoking questions based on prior knowledge of science concepts without teacher probing. For example, on the questionnaire one student listed plants as a topic they recalled studying. Following the question the students were prompted to list any questions they might still have on the topic. Here, the student wrote, “What would happen if plants didn’t have water?” After reviewing the questionnaires, I interviewed Nina to validate her inquisition. I asked her, “What *would* happen if plants didn’t have water?” She replied, “They would die.” Other topics students recalled from

past studies varied; six students listed space, five students recalled plants, two listed socks and shoes, two more said animals, and each of the following topics were mentioned once: bacteria, gasses, matter and soil.

Upon completion of the study I passed out the same questionnaire, but asked the students to reflect upon this year's science program. Thirty-three questions were evident on the fourteen questionnaires collected. The students' "What if..." questions pertained to science inquiry activities we had performed during the study and they opted to change variables that they had not manipulated during the inquiry activity. For example, one student recalled the terrariums we made to represent an ecosystem. One question she still had was what would happen if a terrarium was placed in the freezer. This inquiry communicated a question that was not nonsensical or one that could be answered without investigation. When she brought her questionnaire to me, I asked what she thought would happen. She was able to inference that the plant would probably die because it was from Florida, a warm state, and would not have the necessary adaptations to survive. This made me think of winter and germination, and I was able to encourage her to follow up with her idea on the upcoming science fair. Another student asked what would happen if they had introduced grasshoppers to their terrarium, and yet another student asked what would happen if they placed theirs in the sun. These were all very testable questions and I encouraged each of them to pursue their ideas for their science fair projects. Obviously the results and the impact this will have on the students will not be in this study, but I inferred that their results would only further their interest and questioning abilities.

The students referenced every inquiry topic we researched this year, beginning with the very first week of school. The topics that were listed on the post-questionnaires were: mass, building things, the rock cycle, owl pellets, human body, ramps and rollers, float or sink, warm and cold-blooded animals, groundwater, soil, planets, plants, clean water, and the water cycle. They even incorporated modeling into one of the topics we studied because we made a model of the Florida aquifer and of an ecosystem.

Most of the students were able to ask different, testable questions, which was something they were not able to do before this study. The results of the questionnaire show a 20% increase in the number of logical questions posed by the students that were based on an understanding of the science topic. The scientific inquiry activities had enabled the students to become more comfortable asking such questions that pertained to scientific concepts covered during the study. They were transferring information learned within a different context and making sense out of science concepts. The questions evidenced this through the students' responses. The questionnaires demonstrated students' ability to recall science concepts covered during the course of the study, as well as an improvement in their ability to ask questions that are testable and inquiry-driven.

Teacher field notes recorded several instances where students' communication about scientific concepts improved. At the onset of the study, students gave minimal justification when asked how their group came up with ideas. They communicated answers that were sparse and lacked details. An example of an earlier inquiry activity is discussed. The students were working within their cooperative groups to classify vertebrates based on similar characteristics. The inquiry activity was the fourth one of the study and took place in September, 2005. One group (containing two members of the

first soil group quoted above) said, “Amphibians are frogs. When a (sic) animal that lives on land and water, scales.” Another groups said, “Reptiles, they have cold skulls (sic) cold blooded some have sharp teeth.” While some of these classification characteristics are correct, the students did not justify their answers with rich description and details as are evident in the soil justifications above.

In comparison, as students experienced science inquiry activities and became more comfortable working within a science inquiry environment, their communication demonstrated an understanding of science concepts through rich details and a command of scientific language. One example of such communication was demonstrated during one of the volunteer scientist’s presentation. After presenting the “Waste-stream Story” she was discussing where trash goes. She referenced motor oil sitting in the driveway and asked where it goes. One student inferred that the oil would run into the “watershed” and filter down to the “aquifer” both of which were concepts presented by another volunteer scientist earlier in the study. Several students agreed with her statement and solidified their understanding of how water, and pollutants, filters through the ground into the aquifer.

In another instance towards the conclusion of the study, another scientist volunteer was asking the students which soil they thought would hold the most water based on the observed properties of the soils. The students were working within their cooperative groups to describe the properties and create names for the different soil types. Each group justified the name they chose for the soils. Then they had to investigate the soil and determine which one they thought would retain the most water and, again, justify their reasoning. Their justifications had become rich and descriptive. One group

suggested the “beach sand” because, “Water always rushes up on the beach and it holds it. It couldn’t be the potting soil because when it rains it goes through it to the roots of plants and into the aquifer and it couldn’t be the rocky soil because the water would flow over the rocks.” The justification exuded confidence and understanding of different properties of soils and also went into much more description than justifications offered in the beginning of the study. Another group implied, “The black soil would hold more water because it is packed together. The more packed together the soil is the less water will soak through.” These responses showed a maturity in the students’ ability to communicate about different science ideas.

Students’ use of scientific vocabulary also increased over the course of the study. For example, the students and I were brainstorming different ideas for our upcoming science fair and one of the students said, “Animals that eat other animals.” I wrote the student response on the board and KC raised her hand and said, “Mrs. Luke, you didn’t use the correct term, it is carnivore. Remember? Herbivores eat plants and carnivores eat meat.” On the Density Discovery Logs students also used the correct terminology when asked how they were going to find the volume of their objects several wrote, “displacement” and then described what that term meant. Others used the terms “more dense” or “less dense” to describe whether objects were going to sink or float in their predictions (while some simply said float or sink). The science inquiry experiences improved students’ ability to communicate about science concepts presented during the course of the study.

Student Perceptions of Science and Scientists

Research Question #2: How did working with local scientists affect students' perceptions of scientists?

The DAST was given prior to the first scientist visit. Using field notes that were taken by the teacher researcher and videotaped discussions at the onset and conclusion of the study, data was triangulated to support evidence of the emergent theme: students' perceptions of scientists were less stereotypical. The presence of stereotypical, fantasy careers and people in science declined from the students' initial perceptions into a more real-world perception.

Results from the first DAST revealed that most students have a stereotypical view of scientists that align with previous research findings. Seventy-nine percent of the students drew Caucasian scientists and 64% were men (15% contained ambiguous gender). Other indicators of stereotypical perceptions of scientists were present. Fifty-three percent of students drew flasks and 60% drew test tubes. Twenty percent of the scientists drawn were shown wearing a laboratory coat and there was at least one stereotypical item present in the compilation of drawings.

Contrary to research findings, only 20% of the students drew an eccentric male, eccentric meaning wild-hair, blood-shot eyes, and unkempt appearance. Another unexpected outcome was the presence of female scientists drawn by 21% of the students, along with 33% of the students drawing scientists in a positive environment. A positive environment in this study was interpreted as a scientist in an outdoor laboratory conducting research or working in a realistic field. For example, one student drew a scientist studying plants, sitting in a chair, reading a book. Another drew a scientist in a field looking for dinosaur bones. Other than these exceptions, most of the student

drawings depicted indicators of stereotypical images aligned with previous research on elementary students' perceptions of scientists.

Upon completion of the study, and exposure and interaction with five scientists from the community, I asked the students to take the DAST again, looking for the same stereotypical images, or lack thereof, as noted earlier in this section. For the most part the drawings were very different. They showed a more realistic view of scientists working in fields that are prevalent in our society. 69% of the drawings depicted outdoor laboratories with scientists looking at different types of soils, looking for dinosaur bones, studying animals, researching the aquifer, etc. Tables 1 and 2, display the results of the DAST that was given at the beginning of the study in August 2005, and the results of the DAST at the conclusion of the study in February 2006. Table 1 contains characteristics that could be indicated more than once on student drawings, whereas Table 2 is exclusive to only one characteristic per drawing.

Table 1: DAST Results

PERSONAL CHARACTERISTICS	August 2005	February 2006
Laboratory Coat	20%	0%
Eyeglasses	13%	7%
Pencils/pens in pocket	13%	0%
Unkempt Appearance	13%	0%
SYMBOLS OF RESEARCH		
Test tubes	60%	38%
Flasks	53%	31%
Microscope	6%	0%
Bunsen Burner	13%	0%
Experimental Animals	20%	7%
Other	13%	
SYMBOLS OF KNOWLEDGE		
Books	6%	7%
Filing Cabinet	0%	23%
Other	0%	7%
SIGNS OF TECHNOLOGY (PRODUCTS OF SCIENCE)		
Solution in glassware	53%	38%
Machines	80%	38%
Other	0%	23%
OVERALL APPEARANCE		
Eccentric	20%	31%
Sinister	6%	7%
Neutral	60%	7%
Positive	33%	69%

Table 2: Exclusive DAST Results

HOW MANY DRAWINGS DEPICTED WOMEN AND MEN?	August 2005	February 2006
Drawings of men	64% n= 9	24% n= 3
Drawings of women	21% n= 3	38% n= 5
Drawings in which you cannot tell if scientist is a man or woman	15% n= 2	38% n= 5
DESCRIBE THE RACIAL/ETHNIC GROUP OF THE SCIENTIST		
Appear to be Caucasian	79% n= 11	69% n=9
Appear to be African American, Hispanic, or Native American	0%	0%
Appear to be Asian or Asian American	0%	0%
Not evident	21% n= 3	31% n=4

The data, when compared, revealed a positive change in the students' perceptions of the gender of a scientist. There were more women scientists than men drawn in the second DAST. This perception could be attributed to the gender of the scientists that visited the classrooms. The environmental scientists who worked with the students or presented materials were females.

Another indicator of change is the lack of stereotypical images present in the drawings. Only one student drew a scientist wearing glasses, and no students portrayed them wearing lab coats, carrying pens and pencils in their pockets, or having an unkempt appearance. The percentage of test tubes, flasks, and experimental animals decreased as well. More books, filing cabinets and signs of research were depicted within the second DAST drawings and more uses of “other” technology. The technologies noticed were trowels, computers, and a shovel like device that two of the volunteer scientists worked with the day they visited the classroom.

More than half of the students, 60%, drew scientists at work in realistic scientific jobs. Considering the careers of the scientists the students were associated with during the study, this change could be correlated to the students' interactions with the volunteer scientists. The scientists who visited worked with LPG Environmental, the St. John's River Management District, Lake Soil & Water Conservation District, and Lake County Environmental Services. We also researched scientists who work with soil on the Internet. The students' drawings depicted some characteristics of the volunteer scientists, such as women working outside with soil, digging in the ground, showing movies on water conservation, and working with water.

One odd result of the second DAST, when compared with the first one, was the increase in the percentage of students who drew eccentric scientists. The view of eccentric scientists is an indicator of stereotypical images. The appearances of the scientists the students were exposed to were not unkempt or unruly in nature. Furthermore, the drawings that do not depict a race were very elementary in nature, presenting stick figures with characteristics that were more eccentric than traditional. They were drawn with pencil, so race was unable to be insinuated by the drawings. Although the visiting scientists were all Caucasian females, the students were exposed to scientists of races other than Caucasian during a webquest on soil. This exposure did not seem to have an effect on the students' perceptions of scientists as Caucasians.

Research Questions #3: How did students' experiences with scientists affect their perceptions of science?

Students' perceptions of science were measured at the onset of the study using the DAST. Discussions were videotaped in August, 2005, and revealed that their perceptions were stereotypical in nature. For example, they depicted scientists working in laboratories with cracked light bulbs, trying to bring monsters to life. As the study continued, the students were exposed to five volunteer scientists. The scientists discussed the different aspects of their jobs with the students. Their jobs included surveying land for different types of habitat, testing moisture levels in wetlands, water quality surveys and testing, research, recycling and energy saving, mathematics, and excavating. At the conclusion of the study, students took the DAST again. Field notes and videotaped discussions combined with the pre and post DAST revealed students' perceptions of

science had been positively affected. They no longer thought of science as an isolated subject taught in school, but rather viewed it holistically across curriculums. They also perceived the career choices in science fields as attainable and realistic. Triangulation of field notes, videotaped discussions and the DAST were used to validate the emergent theme.

Field notes depicting students' communicating about science concepts in other disciplines revealed a reoccurring theme. Students' perceptions of science have become more real world. The local scientists that visited the classroom knew the focus of my study. They discussed how their job fit into the community and different activities they engaged in daily. One scientist iterated to the students that her job as a scientist isn't just to do science, but rather to do math and geology. She explained how she perceives herself to be a mathematician and a geologist, as well as a scientist. The students showed understanding of this myriad of roles a scientist takes on through their conversations within different subject areas.

One day during social studies, we were discussing the Seminole Indians and their use of pottery. The social studies text presents their use of pottery as an improvement to their society. At this time, KC raised her hand and suggested that pottery was technology. We had discussed the impact of computers and how they bettered our society by making things easier and providing the world at our fingertips. She went further into this idea when I asked why by saying, "They are like scientists, and they invented something that made their life easier." She was able to transfer her image of scientists and their use of technology into other disciplines.

Other students had similar discoveries in mathematics. We were reading thermometers in one lesson of our mathematics texts and Caleb said, "Why is this in our math books, this is science." Before I had the chance to reply Rob said, "That one lady said she does math everyday." He was referring to the environmental scientist who told the children that scientists are also mathematicians. The students had transferred the ideas that scientists do math based on what the scientists portrayed during their visits and it had stuck with them.

I now have several students who have verbalized their intent to become scientists when they grow up. KC is especially excited and recently told me one morning that she told her mom she was going to be a famous scientist and her mom told her that she could then support her because of all the money she is going to make. She also chose a female scientist recently featured in our Time for Kids issue. She stated, "I want to prove there are female scientists." She also wrote to Time for Kids about their article on successful women in mathematics and science discussing her intent to pursue a scientific career. With this type of intrinsic motivation planted, the students at this age, hopefully some will stick with their dream and become the in-demand scientists that we so desperately need.

Students' perceptions of science as a subject also changed as a result of the study as noticed in the videotaped discussions the class had at the onset and conclusion of the study. The students participated in group discussions continuously throughout the course of the study. These discussions were videotaped. The initial discussion that took place in August 2005 was videotaped and compared to the discussion that took place in February of 2006. This comparison revealed the emergent theme's presence. Rather than giving a

survey, I chose to keep the discussion informal, seeking students' unhindered and unprompted responses. I asked the students what they liked and disliked about science class and their answers revealed that students enjoy science inquiry activities more than the traditional science classes they have experienced in the past.

Some of the transcripts from the first videotaped discussion went as follows:

Teacher: What experiments have you done in science before this year?

Ricky: We did a class science experiment and put seeds on paper towel in a baggie. It was for the science fair last year and we did it as a class

Teacher: What was the hypothesis for your experiment?

Ricky was unable to provide an answer and neither were his peers who were also in that class last year.

Teacher: What did you learn from the experiment you just described?

Ricky: To see the roots growing.

Gabe: To see how fast the roots grew.

Another group of students told me about an experiment that they did about why we wear shoes, but could offer no additional information.

Teacher: How did you do that experiment?

KC: By taking our shoes off and walking around

Teacher: What happened next?

No one was able to answer. Moreover, students said that they only did experiments, "...like once or twice in a year or three times maybe."

Shelia: Like mostly we just read from the book and learn the words.

Natalie: My teacher likes to do Jeopardy to review for the tests.

Teacher: What did you guys like most about science?

Several students: The experiments!

Trisha: We never have experiments though.

Teacher: Raise your hands if science is one of your favorite subjects.

Six students' raised their hands.

Shelia: Science is boring.

Shelia's statement was resounded in two other students who viewed science as negative and just another subject to be reckoned with. The science inquiry method was new to every student participating in the study. The third grade teachers at the school participated in past science fairs, so they had been exposed to scientific thinking, and a form of inquiry, however according to the third grade teachers the students are walked through the steps of the science fair experiment the experience is still teacher directed.

After the first play day, evidence of students' perceptions of science as not only "boring," but challenging and dependent upon the teacher emerged. Several students asked for help repeatedly throughout the first few inquiry activities and showed dependence on the teacher as a director of knowledge by continually asking, "Is this right?" Eventually, as the students became more familiar with science as inquiry, these questions dissipated. The students' began to inquire about science day on Monday mornings when they returned to school from the weekend and again on Wednesday mornings. Their grades began to improve and the final discussion revealed their perceptions' transformations.

Teacher: Why did you guys like most and least about science this year?

Shelia: It isn't boring anymore, it's like more fun. Not like last year.

Shelia could be described as an introvert, who seldom works well within groups. She is also labeled LD and has emerged as a leader during our science inquiry activities. Recently she has become more involved in problem solving during mathematics.

Gabe: I like that we do things, we don't just learn words and take tests.

Jim, Ricky, Rob: yeah.

Gabe: We get to make up our experiments.

Jim: Science day is my favorite day of the week.

All the students in fourth grade loved science day. Every Wednesday they would enter the classroom asking if we were going to do science day

Teacher: What experiments have we done in science this year?

The students were able to compose a list of every single science concept we had studied since the beginning of the school year. This was a key indicator that the students' perceptions of science had been positively affected by the use of scientific inquiry and having local volunteer scientists work with them.

The DAST was given as a pre and post test. The pretest revealed students' stereotypical images of science careers. There were nine drawings, out of fourteen, depicting scientists working in some sort of laboratory, evident by the beakers, test tubes, and bubbling potions. Their written descriptions indicated the eight of the nine drawings depicted the scientist mixing chemicals. One student wrote, "I wonder what will happen when I mix these," as a thought coming from their scientist's head. Another student wrote, "It is a girl scientist is (sic) mixing cimicals (sic) together. The blue cimicle (sic) mixed with the red cimical (sic) and turned into purple. Then we mixed the Green and blue cimicle (sic) together! Purple and green made a reaction!!!!" While these represent

stereotypical images of science careers, two students' images depicted nonsensical careers. One showed a boy holding potions and a monster across from him. The description read, "he is a boy. he is making a monster and mixing up pothens (sic). and there is a robot i (sic) the back ground." The other student drew a person holding a bubbling potion next to a man laying on a table. There were signs posted saying, "Science lab Stay Out." There were also materials such as flasks and beakers in a cabinet labeled, "Materials." The description read, "My science person is trying to revive the perso (sic) he wont's (sic) to see if his new pottion (sic) will work If it works he will sell it if it dosent (sic) The (sic) he will do some miner (sic) ajustments (sic)."



Figure 1: Caleb's Pre DAST

The remaining five pictures depicted science careers that were less stereotypical. For example, one student drew a man sitting at a computer holding a book titled, "Science." His description read, "I drew a man studying plants. He is holding the book and typing on the computer. He wants to do an experiment to see if plants grow without soil." This response was atypical. Only one other student depicted a realistic picture of a man standing in a desert with a shovel. There was a bone above the ground, and one still below. He wrote, "A scientist finding dinosore (sic) bonse (sic)."

Throughout the course of the study, the students interacted with five women scientists from the community. The scientists described their careers and the work

associated with them. Two of the scientists brought a work tool with them, and let the students use it to test the soil in three different areas of the school, looking for the presence of wetlands. They also showed their work boots, which were rubber boots that had straps like overalls to keep them on. They went all the way up to their hips. The discussions with the scientists were rich in detail concerning their jobs. The students were also exposed to other science careers on an Internet Webquest featuring soil. The website featured eight different scientists with careers in several different fields, all concerning soils. Better yet, it indicated the level and type of education pursued and a narrative statement telling why the scientist chose that field. Several scientists talked about traveling and even displayed pictures of various places of interest that their careers had taken them to. The discussion that followed this webquest included the students' thoughts on the travel available to scientists. This broadened their perspectives and was evident in the post DAST.

The post DAST administered at the conclusion of the study contained eight students depicting realistic science careers. Four of the realistic depictions were drawn by girls and displayed the women scientists in one of the careers showcased within the study. For example, KC drew two female scientists that had the tool used by two environmental scientists. Her description said, "The two scientist (sic) are tring (sic) to figure out what dirt this is?" Another drawing by Nina showed a female scientist with a table in front of her that contained different colored soils. In the background were two televisions showing a movie on water conservation and types of soil. Her description read, "The scientist is showing the kids about the environment. And she is showing the kids two videos one a soil and one a water movie. And she shows them different kinds of

soils.” The career choices presented are realistic depictions of scientists and are achievable by normal (non-stereotypical) people.



Figure 2: Caleb's Post DAST

The four remaining pictures that depicted non-stereotypical science careers displayed several different career options. One depicted a female scientist recording information on a report about the temperature. This might not indicate a specific job, but does depict realistic duties careers in science demand. Another student drew a figure looking for dinosaur bones, and another showed an astronaut on the planet Jupiter. There was a space shuttle drawn on Jupiter with a line tying it to Earth, as if to depict the shuttle flying from Earth to Jupiter. The description read, “An astronaut studying storms on Jupiter.”

One other interesting picture was Luke's. Luke drew the picture described on the pre DAST of a man trying to bring a monster to life with a robot in the background. Luke's post DAST revealed a man standing in front of a large bear. He has a book in his hand titled, “Animal book.” The description read, “studing (sic) a koidak (sic) bear.” His perception of scientists had changed dramatically, and noting his change solidified the emergent theme that students' perception of science had become more realistic. They exhibited knowledge of different fields of science and careers that real scientists do every

day. They also demonstrated that science is not male dominated, which could be correlated to their exposure to five female scientists throughout the course of the study.



Figure 3: Luke's Pre DAST



Figure 4: Luke's Post DAST

The remaining five drawings depicted scientists working with test tubes, mixing chemicals, etc. They were all drawn by boys. One of the drawings depicted a male in a laboratory with a cracked light bulb. However, his description read, “Where we learned about sand and clay so we can learn.” Looking at the drawing a second time, I noticed an aquarium with a layer of water, then clay, then sand. Even though the laboratory was stereotypical, the action was not.

Their DAST results, field notes, and videotapes of initial and final discussions revealed a more real-world approach to science and the careers available to scientists.

Another theme that emerged from the data was that students' perceived science as a subject that is used in other subjects. The emerging theme was triangulated using the pre and post DAST, field notes, and videotaped initial and final discussions about their experiences with science.

Role of the Teacher within a Science Inquiry Classroom

Research Question #4: How did science inquiry affect my role as a teacher?

Data analysis of the role of the teacher in an inquiry driven classroom revealed an emergent theme that the role of a traditional teacher changed to a facilitator role to facilitate a successful science inquiry classroom. The way I traditionally taught science and led experiments was teacher driven. The lesson's concepts were introduced, then modeled or researched through the textbook. Guided practice during the experience was provided and finally an assessment was done. Inquiry is student driven, and requires the teacher to facilitate the learning rather than use direct teaching of concepts as the method of instruction. There are several evidences that indicate a transformation from traditional teacher to facilitator is required for successful inquiry experiences. Triangulation of field notes, videotaped inquiry sessions, and teacher reflections provide the evidence to support the emergent theme of change.

Analysis of videotaped inquiry activities revealed a change in my interactions with the children as the study progressed. Videotapes of inquiry activities recorded at the onset of the study revealed students apprehension when I would approach their group. Pseudonyms were used in place of students' names. For instance, Billy's group was working on classifying pictures of different animals. Their classification required the

group to come to an agreement about characteristics the animals had in common. When he noticed I was walking towards their group, he said, “Come on guys, get to work.” This was followed by him waving his hand in front of the group to get their attention. This gesture alluded to the idea that he was keeping the group moving along. The other members of his group looked quickly over their shoulders to see me approaching and immediately reverted back to their pictures and logs. “Um, let’s see,” Greg said. The students were trying to do what they thought I wanted them to be doing. They were used to a prescribed set of behaviors during science experiments, and were attempting to look like they were doing science the right way. Other groups reacted similarly. When I would join a group and inquire about the way they classified their photographs, they would look up at me and try to figure out an answer that they thought I wanted to hear, rather than tell me what they had come up with. One student said, “Well, we know we are classifying them by groups and that these two go in a group” (pointing to the dolphin and the gorilla). I asked them how they had determined that answer and no one was able to provide justification for their reasoning. I had just left a group that had come to the same conclusion and offered justification. Considering the group sat next to Natalie’s group, I was quite certain Natalie had heard our discussion, which was the reason she provided me with that answer. The students were used to providing a correct answer and being rewarded by the teacher when the one correct answer was given. The students were frustrated with my lack of providing the correct answer or solidifying that their answer was correct.

As I continued to review the videotapes, a different type of classroom emerged, largely due to two volunteer scientists who led an open inquiry activity with the students.

That day transitioned my role more concretely. I was able to move around the groups and listen to their planning, helping as if I was one of them while the scientists overlooked the inquiry activity. One group asked me if I thought they were doing it correctly, and I really did not know. When I told asked them what they thought, they described their justification of materials used. They seemed confident and provided a rich description while describing their contraption. They were also predicting the outcome of their experiment without any prompting from me. This was the first inquiry activity where the students seemed less reliant on me to provide assuredness and direction.

The videotape showed me visiting all the groups four times for more than thirteen minutes per group, and two groups five times. Each time I visited, I sat with the group on the ground and talked to them about their ideas. The students realized that I was not going to be the “Giver of Knowledge” and that I was not assessing their answers as right or wrong when I worked with them. I was now a listener and sometimes a guider, rather than controller. I was able to reach a more intimate level with my students during their inquiry activities and this was observable on the later tapes. I would approach Billy’s group and they would continue with their discussion as if I was not there until I asked a question or a student would include me in the discussion. For example, when the students were working with the scientists on “How Clean?” I approached Luke, Jim, and Rob’s group. I sat down on the ground with their group in a circle. They continued working and then Rob said, “Mrs. Luke, we’re going to put paper towels from here to here to see if they absorb the water.” He was not asking for my approval, but explaining his ideas to me, as if I was another student.

Another indicator of my role changing from director of knowledge to facilitator were the student led discussions that were captured on videotape. At the onset of the inquiry activities, we would convene as a class following the activities and discuss our outcomes. I was the one leading the discussions in the beginning of the study. The students would provide answers based on their experiences, but would ask minimal questions themselves and seemed afraid if their answers were different from another groups'. For example, during the classifying animals inquiry activity, the students had to determine which groups they would categorize different animals into and then figure out a way to represent that data on chart paper. Next, they had to present their findings to the class. Their presentations were short and appeared uncertain about their classifications. One group changed the way they had represented the information to coincide with another group because they thought the other group's was better, when in actuality, they had it correct already. Furthermore, I had to question and guide them to different hypothesis and science concepts. During the presentations discussed above, the students would hold up their chart paper and say, "This is how we classified the animals," and that was all. I asked, "Why did you put a gorilla in the Mammal category?" Their reply, "They have fur." I asked how they came up with the category "Mammals" and they said, "We knew that last year." The discussions were very dry and consisted of the teacher questioning and probing rather than the students. I constantly revised lessons to extract more participation from the students and worked to improve their communication abilities. Present in later videotapes were student led discussions that required less guidance from me and displayed students leading the way.

One example of such discussion was after the buoyancy discovery log. The students had spent the morning in their groups balancing objects to determine mass, using displacement to measure volume, and using division to determine density. Then they could see if their predictions about objects buoyancy were correct. One student realized that her data was backwards; if the object was denser than the water it floated for some reason. She posed this error to the class. Ricky immediately suggested that she balance the objects again. Nina repeated the balancing and the measurements were different. Rob interjected, “Your scale was wrong.” This led into a discussion about the importance of writing down your process, and doing an experiment more than once to check for errors such as the one Nina uncovered.

While watching the videotape of this discussion, I noticed that I did not say a word during the first thirteen minutes of the discussion. Thinking back, there were several times I wanted to interject, but the students were leading a discussion, constructing knowledge without me. When I finally did offer a suggestion, it was just recommending that everyone examine their data closely to see if the density and outcomes aligned. The students were leading discussions on their own, with little or no guidance from me. This pattern continued to be evident on the remaining videotaped inquiry activities. The emergent theme that prevailed was that my role as a member of the learning community was to provide guidance through questioning within the science inquiry classroom when required.

At the end of each science day I would reflect on the day’s successes and failures according to the goals of the activities. A trend I noticed that supported the emergent theme that I was no longer the director of knowledge, but rather a facilitator, was when I

planned inquiry activities that required my assistance as opposed to inquiry activities that did not. For instance, when the students were classifying animals based on characteristics determined by their groups, the question about warm and cold-blooded animals arose. This was the first student-directed inquiry, and I was very excited in that afternoon's reflection. I was not sure where to find information on the topic, so I searched the Internet and found a website offered by NASA called "Cool Cosmos." In this website was an experiment that allowed children to observe the temperature rising just outside the color spectrum provided when light hits a prism. The phenomenon behind the idea was that Infrared light exists, though not visible, just beyond the color spectrum. Pictures taken with infrared cameras provided on the website, showed heat on different animals and helped us to determine if an animal was cold or warm blooded. This experiment was a disaster. I wrote, "Today was frustrating. The students were not interested in the experiment, due to the lack of participation. Only three students could participate at a time. Jim's group was talking about lunch while I held the prism on the box and Billy was taking the time." Later in the same reflection I pondered, "What could I have done differently?" My involvement in the experiment was actually taking away student interest. It was a teacher directed experiment, rather than inquiry driven even though the students had provided the topic.

Preparation, including thinking through the experiment, was the missing element. Even though I had read the experiment and understood the procedure and outcome, I had not envisioned the experiment and realized I was going to drive the experiment. The next inquiry activity, "How Clean?" facilitated by two environmental scientists was much more successful. That reflection reads, "The students are so excited about today's

inquiry. I cannot believe how well it went, and how into the activity the students were.”

After comparing the two activities, I inferred that the “How Clean?” activity was solely student driven. There were no adults telling them which step to follow, or where to put which material. The students developed their idea, then tested it, then modified it to produce a better product. They even went so far that day as to pose a competition for the following Friday, after learning which group’s water was cleanest and the methods they used.

Following this “aha” revealed within my reflections, several more positive reflections followed, all with the same common theme emerging. The students showed more ownership and pride, along with enthusiasm towards inquiry activities that were developed by them, not me. This reiterated that my role as director of knowledge was not conducive to a science inquiry environment and needed to change.

Another indicator that my reflections revealed was a need to change the way I used to plan. At the end of each reflection, I would list the following week’s inquiry activity (basing it on students’ interaction with that day’s inquiry activity). The following six days between science days were spent gathering or purchasing materials and inservicing the other fourth grade teachers on the nature of the next inquiry activity. In the past, I was a long-term planner with all of my science lesson plans done for an entire nine weeks. For this study, I used the ongoing reflections to assess where my students were and where they wanted to go, allowing students to drive the curriculum, rather than the traditional teacher who plans sequential lessons based on text or standards.

Previously, the text was the most dominant resource used when creating lessons and experiments for the students to partake in. It was convenient and conveyed the

science concepts in a manner I was comfortable with. For this research study, the students' inquiries guided the instruction, and therefore the book did not always provide the needed resources or the best ones necessary to convey the science concept to be learned. Therefore, I had to step out of my comfort zone and increase my resources. I looked to other teachers, scientists, the Internet, different professional publications, and other science books that were purchased previously, or solely for this study. Teacher made discovery logs. The ability of these resources to aid the science inquiry process was much more than a textbook has ever offered. The role of the teacher changed from someone who has experiments and lessons planned from a prescribed textbook to someone that explores many different options to meet the needs of the students that have been expressed within the inquiry environment.

Over the course of the twenty week study, fifteen inquiry activities were implemented. For preparation of the fifteen inquiry activities, six came from sources on the Internet. A Solid/Liquid/Gas Webquest was located and manipulated for the students to generate a Know/Want to Know/ Learn (KWL) brainstorming activity before embarking on the buoyancy inquiry. Another pre-buoyancy activity was the liquid layers, shaving cream, and oobleck inquiry activities. The Warm/Cold-Blooded animal inquiry activity was founded on the Internet at the "Cool Cosmos" Website (<http://coolcosmos.ipac.caltech.edu/>), a resource provided through NASA.

The volunteer scientists also provided resources for me to use. The "How Clean?" inquiry activity was produced by two of the scientists. The "Soil Discovery" and the edible aquifer was also a product of the volunteer scientists. Models used as resources were another aspect the volunteer scientists brought to the study. One

environmental scientist presented a lesson on the Florida aquifer and water conservation using a model of the aquifer and a separate model of run-off waste in watershed areas.

Use of the text Nurturing Inquiry (Pearce, 1999) to stimulate my students' involvement with science inquiry was another, different resource used. The first inquiry activity my students participated in came from chapter three. This text also provided the Questionnaire I used to assess my students' understanding of past science concepts and provided suggestions for making inquiry implementation successful within the classroom.

The Density Discovery Logs and Classifying Animals inquiry activities were a collaborative effort. My fourth grade team worked together in a collegial setting, discussing different ideas on how to bring inquiry into different topics and get the kids started on the path to inquiry. The science text Harcourt Science (2000) was referred to for the modeling of an ecosystem using terrariums. The outdoor soil exploration was also a result of the prescribed science text.

Every assessment was created by me, based on the experiences the students had during their inquiry activities. This was done based on the ideas of constructivism, that if the students constructed the knowledge of the concepts when they were manipulating them within the science inquiry activities, then the tests would be an accurate reflection of the new schema in place for the child after the experiment. I used the field notes, videotaped discussions and reflections to determine content on teacher made assessments. The discovery logs were modeled after different inquiry methods and both assessments and logs required higher level thinking skills such as justification and synthesis of inquiry activities with concepts.

This was continuous throughout the study, unless the students did not express a want to dig deeper into a subject which was seldom. This changed the way I planned too. No longer were my lessons planned a semester at a time, but instead, they were developed between each meeting, which allowed me the weekend to plan different inquiry activities. Towards the end of the study, when the students became more comfortable with scientific inquiry, I challenged them to create the activities themselves, which again, was different from my past experiences. The reflections evidenced this change. In my reflections I documented the preceding lessons along with different inquiry skills that needed focus, such as recording. Then, the following week's activity would require better recording efforts. The terrariums we studied are an example of this. The students were instructed to choose a variable present in the terrarium and change it. They had to record their changes and document observed changes daily. They also had to document the different ways they manipulated their variable. For instance, one group changed the amount of water plant A would receive. Plant B got a quarter cup of water every other day, where plant B got a half cup every other day. Plant B was flooding after the fourth day. The students had to document what they observed, how much water the provided plant A and plant B, and what they thought was going to happen based on the previous week's observations. This emphasized recording and we were able to discuss why detailed records are required. The reflections allowed me to emphasize different inquiry skills while visualizing scenarios and planning questions that would facilitate learning. Several of these actions validated the change in my teaching practice that occurred as a result of the science inquiry environment's requirements to be successful.

Summary

Science inquiry improved several students' ability to communicate about science concepts. The presence of volunteer scientists provided students a real-world depiction of science careers and scientists. This depiction allowed them to demonstrate realistic perceptions of scientists through the post-DAST. It is also clear after triangulating data that my role became a facilitator of knowledge as the study progressed. The results of the study provided answers to the following questions for this action research project:

1. How did science inquiry experiences affect students' ability to communicate about science concepts presented during the course of the study?
2. How did working with local scientists affect students' perceptions of scientists?
3. How did students' experiences with scientists affect their perceptions of science?
4. How did science inquiry affect my role as a teacher?

Pre and post questionnaire data aligned with discussions the students participated in during the study indicated students' ability to communicate logical questions based on an understanding of scientific concepts learned throughout the course of the study. The pre and post DAST data combined with the discussions revealed students' images of scientists and science were more positive, depicting less stereotypical scientists in realistic settings. My role as director of knowledge changed to facilitator and was evident in the triangulation of discussions, field notes, and reflections.

Chapter five discussed the conclusions based on research and data analysis. The limitations, assumptions and recommendations for future research in this area were discussed and the study concluded.

CHAPTER FIVE: CONCLUSIONS

The purpose of this study was to determine the effects of science inquiry on students' ability to communicate about science concepts, their perceptions of science and scientists, and the role of the teacher. The curricular unit of study was "The World Around Us." The chapters of study were the Nature of Matter, Energy, Processes that Shape the Earth, How Living Things Interact with Their Environment, and the Nature of Science. The study was conducted over a twenty week time frame within my fourth grade science class with fourteen students. The themes that emerged from the data aligned with the research questions and indicated that students' ability to communicate about science concepts had improved. Their perceptions of scientists and science became more realistic and my role transitioned from a traditional director of knowledge to a facilitator within the inquiry environment.

Conclusions

In this study it is evident that science inquiry can improve students' ability to communicate about science concepts. Logical questioning techniques emerged, displaying students' understanding of different science topics and their abilities to question them further. Students' perceptions of science became more realistic when interactions with scientists occurred during inquiry activities. Their perceptions of scientists became less stereotypical and included a more realistic idea of careers available to scientists. The role of the teacher researcher also was affected. A facilitator of learning emerged over the course of the study. Students constructed their knowledge

based on experiences within the inquiry activities with the teacher researcher facilitating and guiding the learning. These findings aligned with previous studies on the benefits of science inquiry (Carr, 2000; Chin, Brown, Bruce, 2002; Crawford, 2000; Dewey, 2002; Diffily, 2002; Finson, 2002; Keys, Bryan, 2001; Klahr, Nigam, 2004; National Research Council, 1996; Pearce, 1999; Piaget, 1964; Piaget, 1978; Purbrick, 1997; Short, Burke, 1996; Solomon, 2003; Sweeney, Paradis, 2004; Vermette, Foote, 2001; Von Glaserfeld, 1995; Von Secker, Lissitz, 1999;. Yager, Yager 1985;. Zahorik, 1997). These studies suggested science inquiry be used in the classroom.

Kahle (1998) found that an individual's perceptions of scientists are one aspect of attitudes toward science and that this may have an impact on the attention given to the study or teaching of science (as cited in Finson, 2002). "If instructions [in science] were improved and if the affective outcomes could be improved, more persons might elect to pursue formal study of science with more interest, understanding, and commitment than the current system produced" (Yager & Yager, 1985, p. 357). Working with volunteer scientists during inquiry activities provided realistic coverage of scientists. These exposures modified students' perceptions of scientists and science, and increased their enthusiasm and drive to do science because they knew they were working with a professional scientist. The students expressed excitement about science each Wednesday before Science Day began. They also depicted more realistic drawings on the post DAST, to confirm their perceptions of scientists and the careers available in the field of science had become more practical.

Teachers must be the guides, monitors, and support for the learning activities (Piaget, 1978). Constructivist teachers must provide facilitation of inquiry experiences

on which students can construct knowledge and add to existing schemas. During the study, I worked to modify my traditional role of knowledge director to a more facilitator-like role. Encouraging student justification and decision-making, group work, communication, and inquiring further into science concepts created more independent scientists. The students displayed ownership of the inquiry activities, and were emotionally involved in the making and outcomes of the experiences. Students' learning was meaningful. "What we want to develop are students who have the skills to become active contributors to society, who are enthusiastic about what they have learned, and who are aware of how learning can be of use to them in the future" (Glaser & Raghavan, 1992, p. 694). Throughout the study, students demonstrated active contributions to our studying of science and pursuit of inquiry. They were enthusiastic and continuously modified schema to succeed in future inquiries.

Science inquiry fit well into the classroom setting. As mentioned in chapter three, the class consisted of regular education and special education students. There were no differences noted in the abilities of the students to communicate about science concepts. Likewise, the students' perceptions of science and scientists became more realistic, regardless of educational abilities. "Project-based learning, or service learning, in which students volunteer their time, effort, and skills to a social cause can be an effective method of learning for a variety of students, including students with disabilities" (as cited in Carr, 2000, p. 42).

The review of literature and data analysis supported science inquiry's positive affect on students' ability to communicate about science concepts, their perceptions of science and scientists, and the role of the teacher. I will continue to use the practice of

science inquiry to make learning meaningful to students and encourage ownership of learning and inquiry-driven citizens.

Assumptions

Several assumptions were made prior to the onset of the study. One such assumption was that the use of science inquiry as a means of teaching science would improve their ability to communicate science and that working with scientists would change their perceptions of scientists to more realistic views. Another assumption was that students worked to their potential to complete the questionnaire and DAST tests. Also assumed was that science inquiry would have show similar effects on other students' ability to communicate effectively, and that perceptions of science and scientists would be more realistic after exposure to local, volunteer scientists. The final assumption was that I would not influence the data analyzed.

Limitations

One limitation of this study was the short time period in which it was conducted. The study began in August of 2005 and continued until February 2006. No data were gathered from November 17- January 5. If time allowed, I would have liked to continue the research into the students' fifth grade classrooms, researching whether or not students were able to retain information learned during this study and the level of understanding that existed.

Also, I would have liked to measure students' attitudes towards science before the study, and again at the conclusion thereof. This would have allowed me to see any changes in students' attitudes towards science. As this study progressed, the students

were excited about science day. They referenced science as their favorite subject several times, and took part in the discussions and inquiry activities enthusiastically. However, having no data from the onset of the study limits the assumptions that I can make about students' changes in attitude.

Another limitation was the small convenience sample that was the population for the study. It was indicative of the school's setting, but did not include a heterogeneous mix of students, rather a very homogeneous one. Field notes provided a limited feature because there were no visual aids. The videotapes showed my interactions with the students working in their groups, but were not able to capture each group's conversations due to positioning and noise.

One other limitation to the study was the gender and ethnicity of the scientists that visited the classrooms. The volunteer scientists were women. As I was researching different scientific firms in Lake County, it became clear that most of the volunteers from the firms were women. I did not want to specifically request a male, or a specific ethnicity and Caucasian females were the result. While I was hoping for a more diverse selection, I still feel that seeing all female scientists was valuable for the students in the study and that working closely with two of the scientists was a unique and important part of the study.

Discussion

Science inquiry has proven to be a successful method to teach science concepts to elementary students. They were able to communicate questions that were indicative of an understanding of science concepts covered during the course of the study. They were

eager to participate and found science to be fun. “It isn’t boring anymore, it’s like more fun.” This was how all of the students who participated in the study felt about science at the conclusion of the study. “It’s my favorite subject.”

The results of the study suggest that science inquiry within a constructivist environment where the students construct their knowledge based on experiences is a method that could work to teach science in other grade levels. The entire fourth grade team was interested in pursuing science inquiry as a means of teaching science and the administration at Spring Creek Elementary has established a science committee and asked me to be a member. This committee will look at science in different grade levels and help develop successful strategies for teaching students science concepts beginning in Kindergarten. The results of this study could be used to support my suggestion of using inquiry in the classrooms at all levels.

Working with scientists also provided a realistic view of science and scientists. The students enjoyed working with adults from their community. The scientists were positive role models and furthered their interest in scientific concepts. Working with members (not just scientists) from their community could also be an effective method for teaching different concepts.

I also benefited from the partnership provided by the volunteer scientists. My comfort level with science has increased. I am no longer afraid of different scientific concepts because my level of understanding is not perfect, rather I look forward to inquiring about them. This will allow me to learn more about the subject than before, learn alongside my students, and facilitate their learning, rather than direct teach. The scientists provided a support system for me and the students. When we came across a

question that we could not seem to find the answer to or needed a direction to begin our research, we could email them. They usually responded the very same day, or the following day with a recommendation or direction. I will continue to use their assistance and presence in my classroom as long as their schedules allow.

Recommendations

After reviewing the data analysis and conclusions based on the study, there were some changes I would make if I were able to do the study over. At the onset of the study, I would have conducted a pre-test to determine students' level of understanding of science concepts. This would have been followed by a post test given at the conclusion of the study to determine if any learning gains had been made. The students' ability to recall concepts studied over the course of the action research suggested that learning gains might be evidenced if a pre test had been conducted.

I am also interested in continuing this study. Inspired by my classroom setting, I would like to investigate the effect of science inquiry on students with special needs as compared to regular education students. The information gathered would be a valued addition to the research on the effects of science inquiry that already exists. It would also better prepare me to teach the kinds of students that are present within my classroom. Inclusion is an idea that is becoming more popular due to budget cuts and class size reduction laws. My knowledge of how to better serve every student based on individual needs to continually be updated to include best practices in teaching. Researching the effects of science inquiry on students with learning disabilities would allow me to

continue to be an effective teacher. It would also provide my students the best possible learning environment, which is the ultimate goal of every educator.

APPENDIX A
STUDENT QUESTIONNAIRE

PERMISSION LETTER

----- Original Message -----

From: McKenna, Debbie (Heinemann)

To: mytlea23@comcast.net

Sent: Monday, March 06, 2006 9:49 AM

Subject: Permission request

Dear Mr. Luke,

We are pleased to grant you permission to use Figure 2-4, page 17 of *Nurturing Inquiry* by Charles R. Pearce.

We consider the use of the borrowed material to fall into the "fair use" category and we will not request a fee but we do ask that you please acknowledge the book title, author, publisher, and copyright date in a credit line.

Sincerely,
Debbie McKenna

Debbie McKenna



361 Hanover Street

Portsmouth, NH 03801

(603) 431-7894 ext 1133

From: James Luke [mailto:mytlea23@comcast.net]

Sent: Tuesday, February 28, 2006 10:01 PM

To: Wishart, Peggy (Heinemann)

Subject: Copy Request

Mrs. Wishart,

I am currently pursuing a Masters degree in science education at the University of Central Florida. For this program, I am required to conduct action research in my classroom. My action research is on the affects of science inquiry. For one of my data collection strategies, I would like to use the science and questions (p.17, figure 2-4) in Charles R. Pearce's book, *Nurturing Inquiry*. Your attention to this request is appreciated.

Thank you in advance,
Stephanie Luke

Science & Questions

Name: _____

Think of some science topics you studied in past years. Complete the spaces below.

1. One science topic we studied was _____. I am still wondering (write two or three questions):

2. Another topic we studied was _____. Write two or three “what if” questions:

What if...

What if...

What if...

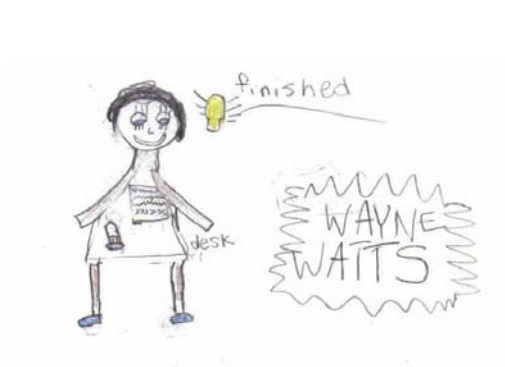
3. Another science topic I remember studying was _____. I never had a chance to try (write two or three things you would like to do):

4. I remember another science topic was _____. (Think about the materials you used. If you could have any of those materials again, what would they be and what would you do with them?) I would like to have _____ materials. Then I would:

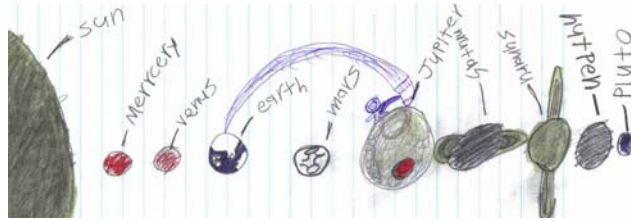
APPENDIX B

DRAW A SCIENTIST TESTS

DRAW A SCIENTIST PRE-TESTS



DRAW A SCIENTIST POST-TESTS



APPENDIX C
IRB APPROVAL AND FORMS

IRB APPROVAL LETTER



Office of Research & Commercialization

August 23, 2005

Stephanie Luke
301 Cricket Hollow Lane
Eustis, FL 32726

Dear Ms. Luke:

With reference to your protocol #05-2764 entitled, "**The Effects of Inquiry on Students' Performance & Perceptions of Science in a Co-facilitated 4th/5th Grade Classroom**" I am enclosing for your records the approved, expedited document of the UCFIRB Form you had submitted to our office. **This study was approved by the Chairman on 8/15/05. The expiration date for this study will be 8/14/06.** Should there be a need to extend this study, a Continuing Review form must be submitted to the IRB Office for review by the Chairman or full IRB at least one month prior to the expiration date. This is the responsibility of the investigator. **Please notify the IRB when you have completed this study.**

Please be advised that this approval is given for one year. Should there be any addendums or administrative changes to the already approved protocol, they must also be submitted to the Board through use of the Addendum/Modification Request form. Changes should not be initiated until written IRB approval is received. Adverse events should be reported to the IRB as they occur.

Should you have any questions, please do not hesitate to call me at 407-823-2901.

Please accept our best wishes for the success of your endeavors.

Cordially,

Barbara Ward
Barbara Ward, CIM
IRB Coordinator

Copy: IRB file
Bobby Jeanpierre, Ph.D.

BW:jm

IRB APPROVAL FORM



THE UNIVERSITY OF CENTRAL FLORIDA
INSTITUTIONAL REVIEW BOARD (IRB)

IRB Committee Approval Form

PRINCIPAL INVESTIGATOR(S): Stephanie Luke; IRB #: 05-2764
Bobby Jeanpierre, Ph.D. (Supervisor)

PROJECT TITLE: The Effects of Inquiry on Students' Performance and Perceptions of Science in a Co-facilitated 4th/ 5th Grade Classroom

- ☒ New project submission ☐ Resubmission of lapsed project # _____
☐ Continuing review of lapsed project # _____ ☐ Continuing review of # _____
☐ Study expires _____ ☐ Initial submission was approved by expedited review
☐ Initial submission was approved by full board review but continuing review can be expedited
☐ Suspension of enrollment email sent to PI, entered on spreadsheet, administration notified _____

Chair

- ☒ Expedited Approval
Dated: 15 August 2005
Cite how qualifies for expedited review:
minimal risk and #7

IRB Co-Chairs:

Signed: [Signature]
Dr. Sophia Dziegielewski

- ☐ Exempt
Dated: _____
Cite how qualifies for exempt status:
minimal risk and _____

Signed: _____
Dr. Jacqueline Byers

- ☒ Expiration
Date: 14 August 2006

Complete reverse side of expedited or exempt form

- ☐ Waiver of documentation of consent approved
☐ Waiver of consent approved
☐ Waiver of HIPAA Authorization approved

NOTES FROM IRB CHAIR (IF APPLICABLE): Action research, minor
Clarifications needed. [Signature]
Aug 7, 2005
Revisions submitted via email 8/15/05.

PARENT/GUARDIAN CONSENT FORM



Parent/ Guardian Consent Form

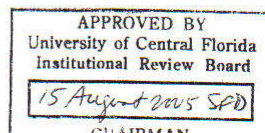
44440 Spring Creek Rd.
Paisley, FL 32767

Dear Parent/ Guardian:

I am a graduate student at the University of Central Florida under the supervision of Dr. Jeanpierre. I am conducting research on the effects that science inquiry has on students' understanding and perceptions of science in the real world. The results of this study may help teachers better understand the perceptions students hold about scientists and allow them to design instructional practices accordingly. Possibly, it could change students' outlooks on the availability of science as a career choice. It might also deepen the child's understanding of the scientific processes and the purposes for science in the real world.

All of the participating children will begin the year in August by taking a "Draw A Scientist Test". It consists of a drawing, interview, and writing activity. The students will not have to answer any question they do not wish to answer. These assessments will help me to determine the perceptions that the children already have about science and scientists. Following the assessment, we will begin our science curriculum with the study of ecosystems. We will be conducting a scientific inquiry project based on barn owls, and a model of the scientific process will be done. Next, Amy Townsend, an Environmental Scientist with the Florida Land Planner Group will be coming in to lead an investigation into water quality and again, they will participate in a scientific inquiry project. Maryann Utegg, the Lake County Watershed Action Volunteer Coordinator with the St. Johns River Water Management District, and another volunteer scientist from Agri-Starts (a local nursery) will also visit and become a lead investigator in our classroom, as the students begin to internalize the scientific inquiry method. A field trip to Trout Lake is a possibility for the students and will be confirmed once the available dates have been provided. The following Sunshine State Standards will be addressed: Processes of Life, How Living Things Interact With Their Environment, and The Nature of Science. Once these visits and projects are completed, the students will take the same assessment they took at the beginning of the semester, so that I can compare the two to see if a difference in their perceptions has occurred. With your permission, your child will be videotaped during the inquiry projects. These video(s) will be viewed only by me, and will allow for careful review of the learning that is taking place during the inquiry process. It will also guide the following inquiry projects, allowing me to make changes for the betterment of the study. The video(s) will be accessible only to me. At the end of the study (which will conclude during the month of June), the tape(s) will be erased. Although the children will be asked to write their names on the questionnaires for matching purposes, their identity will be kept confidential to the extent provided by law. I will replace their names with code numbers.

Participation or nonparticipation in the study will not affect the children's grades. An alternate curriculum will be provided if your child does not participate in the study, based





on the Harcourt Science textbook that Spring Creek Elementary currently uses. It will be facilitated by my co-teacher, Nancy Glass, and will include all elements of the Sunshine State Standards as required by law. The students who do not participate will receive the same standard of education as those that choose to participate.

You and your child have the right to withdraw consent for your child's participation at any time without consequence. There are no known risks or immediate benefits to the participants. No compensation is offered for participation. Group results of this study will be available in June, upon request. If you have any questions about this research project, please contact me at (352) 516-2578 or my faculty supervisor, Dr. Jeanpierre at (407) 823- 4930. Questions or concerns about research participants' rights may be directed to the UCFIRB office, University of Central Florida Office of Research, Orlando Tech Center, 12443 Research Parkway, Suite 302, Orlando, Florida 32826. The hours of operation are 8:00AM until 5:00PM, Monday through Friday except on University of Central Florida official holidays. The phone number is (407) 823-2901.

Yours in Education,

Mrs. Stephanie Luke
Teacher

Please detach this portion and return with your child.

_____ I have read the procedure described above.

_____ I voluntarily give my consent for my child, _____, to participate in Mrs. Luke's study of situated cognition within the science inquiry method.

_____ I will allow my student to be videotaped, provided the tapes are destroyed upon completion of the study.

_____ I do not want my student to be videotaped.

_____ I would like to receive a copy of the procedure description.

_____ I would not like to receive a copy of the procedure description.

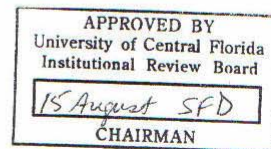
Signature Parent/ Guardian

Date

Signature Parent/ Guardian

Date

July 20, 2005



PRINCIPAL CONSENT

Robert Curry
Principal

Spring Creek Elementary



Delores Deen
Curriculum Specialist

Melinda Watson
Guidance Counselor

44440 Spring Creek Road, Paisley, FL 32767 (352) 669-3275
FAX (352) 669-3762

July 20, 2005

To Whom It May Concern:

Stephanie Luke has provided me with the information regarding the research that will be conducted. I grant her permission to perform her action research provided that the data will be kept confidential and will be destroyed upon completion of the study.

If you have any questions regarding this assent, please contact me at 352-669-3275, Monday through Friday.

Thank you,

A handwritten signature in cursive script that reads "Bob Curry".

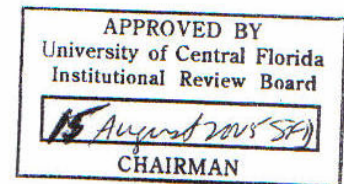
Bob Curry

"Making the best better"

CHILD ASSENT SCRIPT

Child Assent Script

My name is Mrs. Luke, and I am your teacher. I am also going to school, just like you, at the University of Central Florida. Scientists are going to come to the classroom and teach science concepts. After their visits, projects will be done so I can tell that students understand the concept. Grades for the first and second nine weeks will come from the projects that are completed during this time. I would like to ask you to take part in these projects. You may stop at any time during a project and do not have to finish that project, but you will have a different assignment so you can receive a grade. Does this sound like something you would like to do?



APPENDIX D
STANDARDS & BENCHMARKS

The National Science Education Standards

Teaching Standard A	Teaching Standard B	Teaching Standard C	Teaching Standard D	Teaching Standard E	Teaching Standard F
Teacher of science plan an inquiry-based science program for their students.	Teachers of science guide and facilitate learning.	Teachers of science engage in ongoing assessment of their teaching and of student learning.	Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science.	Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning	Teachers of science actively participate in the ongoing planning and development of the school science program.

Science as Inquiry Standards	Physical Science Standards	Life Science Standards	Earth & Space Science Standards	Science & Technology Standards
Levels K-4 <ul style="list-style-type: none"> Abilities necessary to do scientific inquiry Understanding about scientific inquiry 	Levels K-4 <ul style="list-style-type: none"> Properties of objects and materials 	Levels K-4 <ul style="list-style-type: none"> Characteristics of organisms Life cycles of organisms Organisms and environments 	Levels K-4 <ul style="list-style-type: none"> Properties of earth materials Changes in earth and sky 	Levels K-4 <ul style="list-style-type: none"> Abilities to distinguish between natural objects and objects made by humans. Abilities of technology

BENCHMARKS

SC.A.1.2.1: The student determines that the properties of materials (e.g., density and volume) can be compared and measured (e.g., using rulers, balances, and thermometers).

SC.B.1.2.1: The student knows how to trace the flow of energy in a system (e.g., as in an ecosystem).

SC.B.1.2.5: The student knows that various forms of energy (e.g., mechanical, chemical, electrical, magnetic, nuclear, and radiant) can be measure in ways that make it possible to determine the amount of energy that is transformed.

SC.D.1.2.1: The student knows that larger rocks can be broken down into smaller rocks, which in turn can be broken down to combine with organic materials to form soil

SC.D.1.2.3: The student knows that the water cycle is influenced by temperature, pressure, and the topography of the land.

SC.D.1.2.4: The student knows that the surface of the Earth is in a continuous state of change as waves, weather, and shifts of the land constantly change and produce many new features.

SC.D.2.2.1: The student knows that reusing, recycling, and reducing the use of natural resources improve and protect the quality of

SC.G.1.2.1: The student knows ways that plants, animals, and protests interact.

SC.G.1.2.4: The student knows that some organisms decompose dead plants and animals into simple minerals and nutrients for use by living things and thereby recycle matter.

SC.G.1.2.6: The student knows that organisms are growing, dying, and decaying and that new organisms are being produced from the materials of dead organisms.

SC.G.1.2.7: The student knows that variations in light, water, temperature, and soil content are largely responsible for the existence of different kinds of organisms and population densities in an ecosystem.

SC.G.2.2.1: The student knows that all living things must compete for Earth's limited resources; organisms best adapted to compete for the available resources will be successful and pass their adaptations (traits) to their offspring.

SC.G.2.2.3: The student understands that changes in the habitat of an organism may be beneficial or harmful.

SC..H.1.2.1: The student knows that it is important to keep accurate records and descriptions to provide information and clues on causes of discrepancies in repeated experiments.

SC.H.1.2.2: The student knows that a successful method to explore the natural world is to observe and record, and then analyze and communicate the results.

SC.H.1.2.3: The student knows that to work collaboratively, all team members should be free to reach, explain, and justify their own individual conclusions.

SC.H.1.2.4: The student knows that to compare and contrast observations and results in an essential skill in science.

SC.H.1.2.5: The student knows that a model of something is different from the real thing, but can be used to learn something about the real thing.

SC.H.2.2.1: The student knows that natural events are often predictable and logical.

SC.H.3.2.1: The student understands that people, alone or in groups, invent new tools to solve problems and do work that affects aspects of life outside of science.

SC.H.3.3.2: The student knows that data are collected and interpreted in order to explain an event or concept.

SC.H.3.2.4: The student knows that through the use of science processes and knowledge, people can solve problems, make decisions, and form new ideas.

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